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EDITORIAL NOTES.

MR. ARTHUR HUTCHINSON, M.A., F.R.S., Fellow of Pembroke College, Cambridge, University Lecturer in Crystallography, and lately President of the Mineralogical Society, has been elected to the Professorship of Mineralogy in the University of Cambridge, in succession to the late Professor W. J. Lewis, F.R.S.

* * * * *

AN interesting ceremony took place at Bath on 10th July, when Dr. F. A. Bather, F.R.S., President of the Geological Society of London, unveiled a tablet to the memory of William Smith, on the wall of 29 Pulteney Street, Bath, where the epoch-making "Order of Strata" was first written down, thus marking the real beginning of stratigraphical geology. Dr. Bather also delivered a lecture on William Smith and his work, in which he emphasized the practical value to the city of Smith's work in preserving and restoring the springs when in danger of diversion by deep borings in the neighbourhood and also referred to the great work done by other local geologists, especially Conybeare and Charles Moore. It is to be hoped that the lecture may eventually be published in full.

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THE Editor ventures once more to ask contributors to be kind enough to refrain from sending in manuscripts during the six weeks following 20th August. The GEOLOGICAL MAGAZINE has no office, and no staff except the Editor, who is always absent from Cambridge at that time; consequently there is much inconvenience, and a considerable risk of loss, in forwarding such matter.

ORIGINAL ARTICLES.

The Kailpot, Ullswater.

By J. E. Marr, Sc.D., F.R.S.

(PLATE XXIV.)

In my work on *The Geology of the Lake District*, p. 162, I suggested that this pothole was a "giant's kettle" formed by water flowing down a crevasse in the ice.

In September, 1925, I paid attention to it, assisted by Mr. T. Hay, M.A., Head Master of King Edward VI's School, Chelmsford, and Mr. E. C. Palmer, of Lancaster, to whom I would express my thanks.

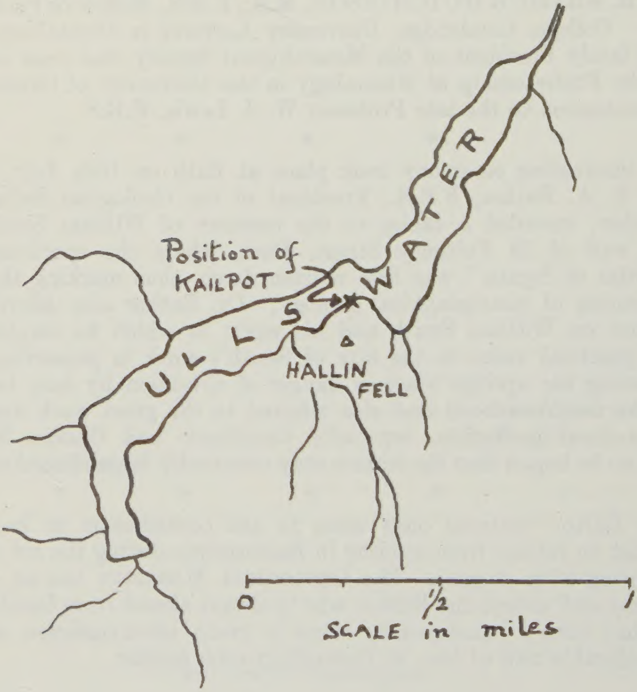


Fig. 1.—Map of Ullswater.

Kailpot Crag, at the foot of which is the pot, is due north of the summit of Hallin Fell, and is situated at the eastern end of the middle reach of the lake (see Fig. 1). It sinks below water-level to a subaqueous shelf separating the deeper basins towards the head and foot of the lake. Hallin Fell rises to a height of 1,271 feet above sea-level, and was glaciated to the top, as shown among other evidence by various overflow channels, two of which occur on the east by the new Martindale Church, while two others are close to the summit.

The Crag itself is the lakeward face of a moutonnée eminence, rising some 30 feet above lake-level, the crag-top being nearly at the summit of the eminence. It has apparently been but little modified since its formation by ice-action. On the landward side of the eminence is a depression, the bottom of which leaves the lake-shore west of the crag, and reaches it again at the east, no part of it being much above lake-level. It was probably formed by ice-erosion. The depression, some yards in length, separates the eminence from the steep northern slope of Hallin Fell behind it (see Fig. 2).

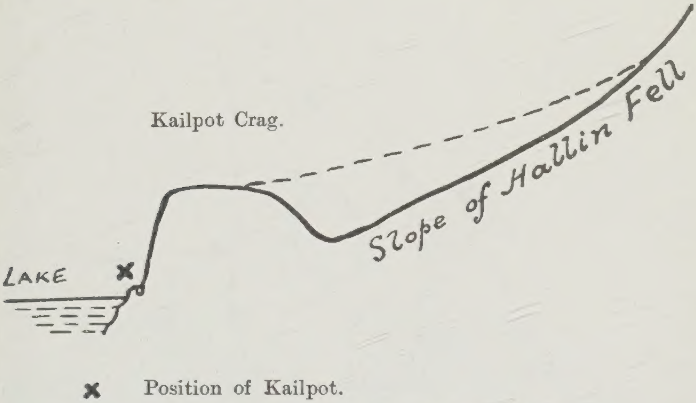


Fig. 2.—Vertical section of Kailpot Crag.

The pot occurs in the even, nearly horizontal floor of a triangular recess in the otherwise unbroken cliff-face. The recess is several feet wide, and extends backwards some yards from the general cliff-face, with which it presents a marked contrast, as it is marked by steep facets and ledges, formed along divisional planes of weakness. It shows, so far as I could see, no definite signs of water-wear, but the same may be said of many of the waterfalls of the district, which flow over rocks riven along the divisional planes. The depression between the crag and the steep slopes of Hallin Fell behind, forbids the supposition that it was formed by a stream coming down that Fell which would have had to flow along the course marked by the dotted line in Fig. 2 unless the depression was formed after the production of the recess, which is most improbable. Again, the line of cliff extending on each side of the recess, passing below water-level, shows that no stream parallel with the margin of the latter caused the formation of the recess and pot.

The recess may have been formed by the tearing action of the ice itself, but its backward extension for some distance at right angles to the direction of flow of the ice, does not accord well with this explanation, and I believe that the recess was formed by a waterfall down a crevasse, combined with weathering action similar to that described by Willard Johnson as "bergschrund-erosion".

The top of the pot was about 3 feet above lake-level at the time of my visit.

The irregular floor of the shelf in which the pot is situated really consists of two minor shelves, in the upper of which the pot occurs, while a smaller pot and also an incipient one are on the lower shelf.

Nearer the lake the shelves show waterwear, which may be due to the action of the lake during storms. The general appearance of the recess, shelves, and pot is shown in the plate from a photograph kindly supplied by Mr. Hay, while Fig. 3 shows the arrangement of the pots.

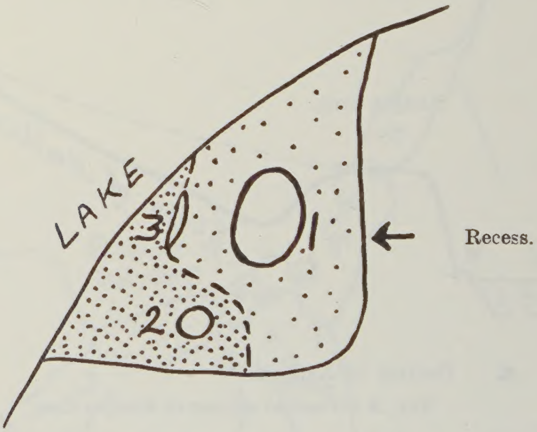


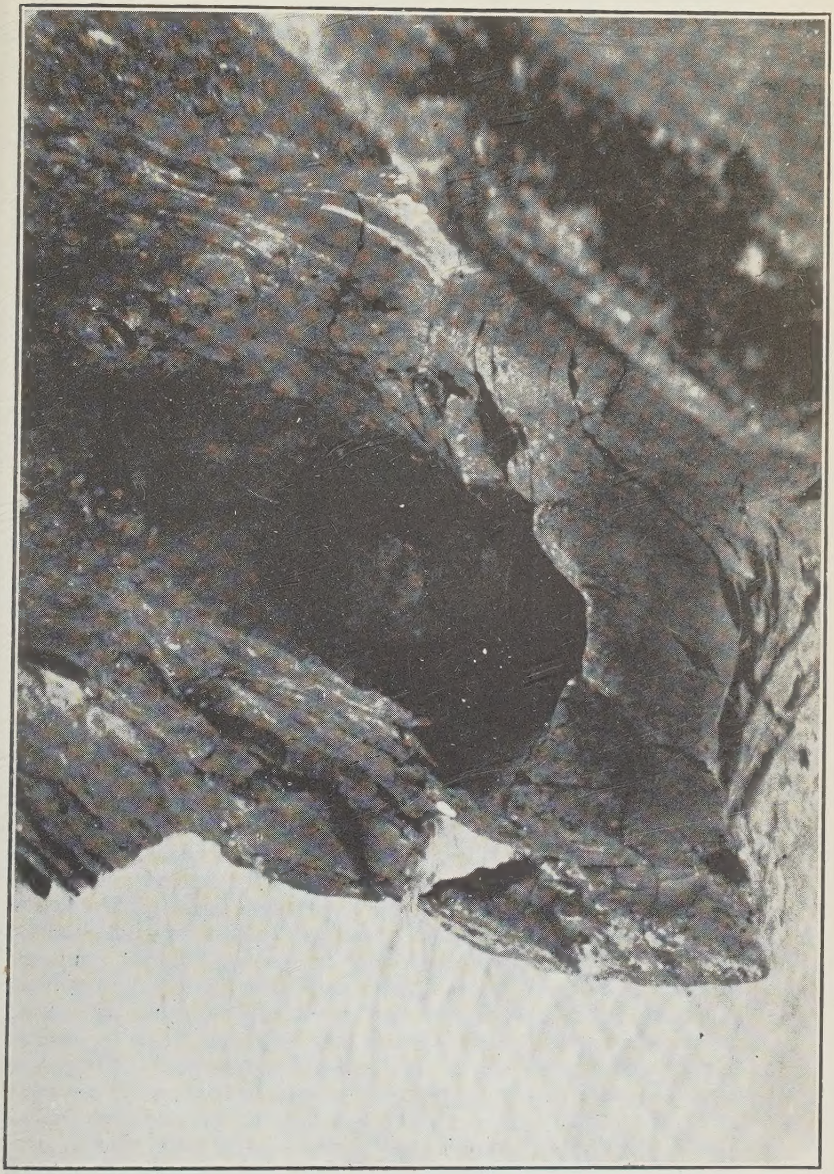
FIG. 3.—1, Kailpot. 2, Small pot on lower shelf. 3, Incipient irregular pot.

The lower shelf with the minor pot is seen in the foreground of the photograph. This photograph was taken from the continuous cliff west of the recess, looking down on the shelf, and showing also the easterly continuation of the cliff beyond the recess.

The Kailpot is semi-oval in vertical section, 2 ft. 6 in. in diameter at the top, and of the same depth. The minor pot, which is 2 feet from the Kailpot, is only 8 inches in diameter and 2 inches deep.

An inspection of the soundings in Dr. H. R. Mill's map of Ullswater (*Geograph. Journ.*, July and August, 1895) shows that an icefall must have existed just east of the Kailpot Crag and at the head of this the required crevasse might well have been formed.

It may perhaps be suggested that the pot was formed by the waters of the lake itself, during storms. I have seen no record of



THE KAILPOT, ULLSWATER.

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any such mode of formation, and surely if pots can be formed in this way cases should be fairly common.

On the whole the view that we are dealing with a true giant's kettle is most in accordance with the observed facts, and considering the rarity of giant's kettles in this country, I have thought it worth while to make record of the Ullswater case. The pots are probably fairly common though generally filled with drift, and the Kailpot would owe its exposure to its position, it being kept open by the waters of the lake.

The only other case of a giant's kettle which I have seen in the district is a poor example on the old road between Rydal and Grasmere. It was recorded over half century ago by, I think, the late J. Clifton Ward, but I am unable to find the reference.

On Some Curious Marks on a Rock Surface.

By J. Challinor, M.A., F.G.S., and K. E. Williams, B.Sc.,
University College of Wales, Aberystwyth.

(PLATE XXV.)

THIS note is a record of the occurrence and character of some curious marks on a rock surface near Borth, Cardiganshire. We do not know of any previous description or reference to marks of this kind.

The rock surface is exposed in patches over a triangular area of about 40 square yards, forming part of the west (seaward) side of a small quarry at the top of the sea cliff, 380 feet above O.D. in lat. 52° 27′ 43″ N., and long. 4° 4′ 8″ W.—¼ mile due west of Bryn-bala farm and about 2 miles S.S.W. of Borth (Ordnance Survey Six-inch Map, Cardiganshire, Sheet 111 S.W.). The rocks here and along all this part of the coast are the well-bedded Aberystwyth Grits—an alternation of shaly and hard, fine-grained, "gritty" beds (each individual bed of shale or grit being measurable in inches), and this surface is in a shaly bed, being a bedding surface and dipping inland (true bearing of dip direction E. 22° N.). The amount of dip varies slightly, but is generally about 30°. The surface tends to flake off readily parallel to the bedding, and also to break up along "joint" planes—of these there appear to be three sets making angles of 60° with each other, one set being approximately parallel to the dip. The lower part of this side of the quarry is formed of talus obscuring the rock *in situ*. This surface shows characteristic slickenside features, and at the lower corner of the exposure the surface is seen to bend abruptly with a steeper slope and to cut obliquely across the bedding for a few inches, resuming, at a slightly lower level, its slope parallel to the bedding. Thus it is evidently also a surface of relative movement, and this is the most significant feature about it, as the marks now to be described are presumably a result of this movement.

These marks are scattered over the surface, and are conspicuous owing to the fact that they are a lighter colour than their surroundings; but they are essentially grooves, usually quite shallow, but the depth varying in different marks and usually in different parts of the same mark. The greater proportion of marks are of about the same depth and width, but others are shallower and thinner and some are mere traces. When the depth varies in one mark it does so more or less regularly from one end to the other. From a glance at the figures and photographs, it will be noticed firstly that these marks are sharply bent, the parts between the bends being straight or slightly curved, and at one end at least the marks are hooked or bent two or three times within a very small space (the exact form of this part is seen only in the "traces" where the line is thin enough not to overlap itself in these small turns). Secondly, while almost identical in their course when only a small piece (say, a few square inches) of the surface is examined, they are of very different patterns in different parts of the whole surface. It was hoped

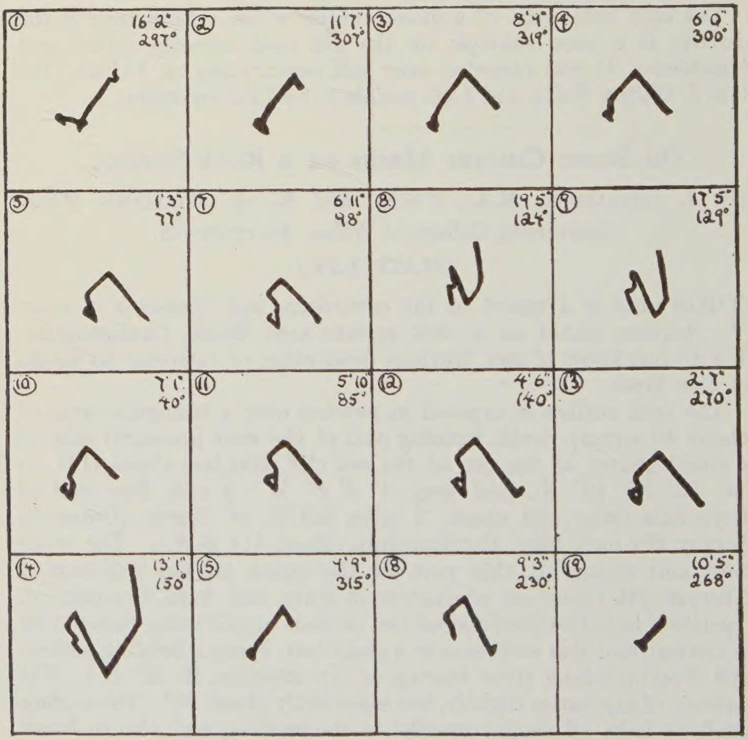
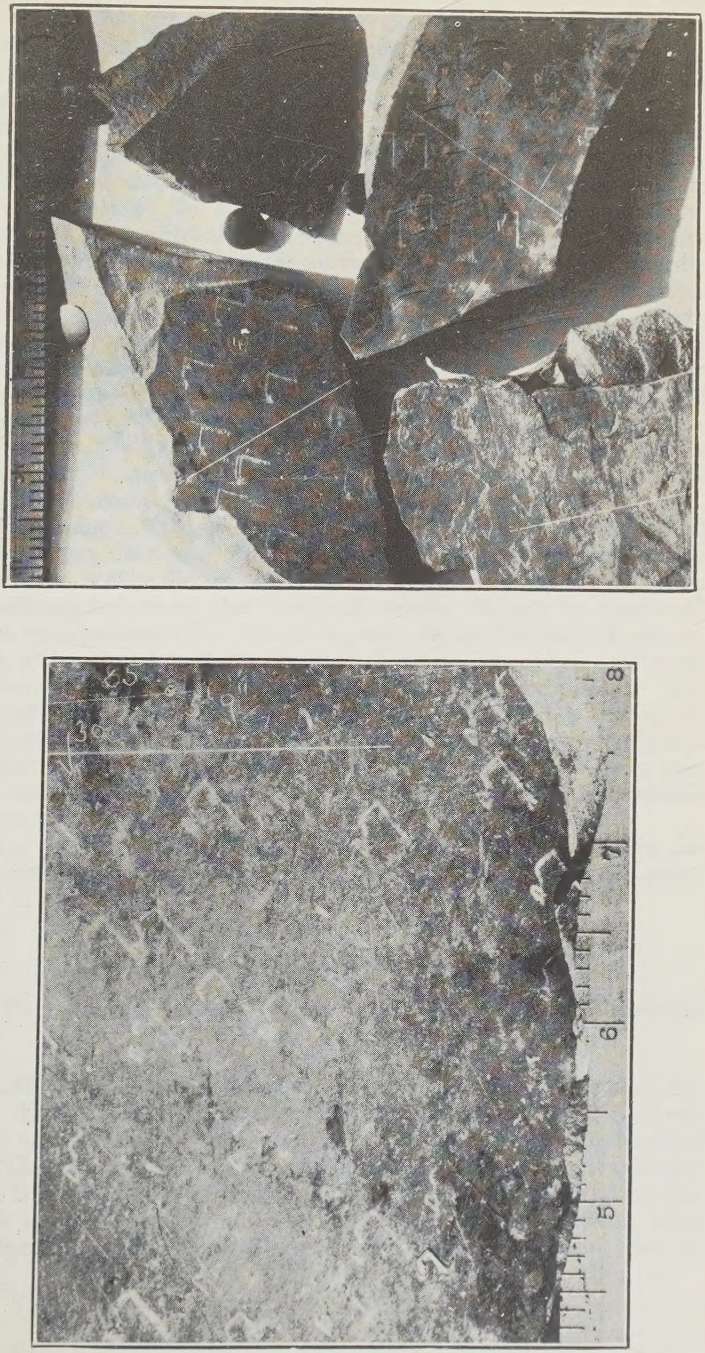


FIG. 1.—Marks on a rock-surface near Borth. Explanation in text.



PHOTOGRAPHS OF MARKS ON A ROCK-SURFACE NEAR BORTH.

[To face p. 342

that these patterns, when their positions had been plotted to scale on a diagram, would reveal some simple manner in which the relative movement had occurred ; but they do not vary uniformly, the rate of variation being very different at different parts of the surface. The range of variation (as far as can be seen on the exposed surface and in one or two excavations through the talus) is covered by the examples figured; the relative positions of each being indicated by linear measurements (to the nearest inch) from an arbitrary datum point marked on the surface in the quarry, and angular measurements (to the nearest degree) with reference to this point and a line drawn from it directly up the surface (i.e. the direction of true dip so expressed is 180°). The horizontal lines separating the individual figures represent the strike, a constant direction. Each of these figures (all are the natural size) shows diagrammatically the general shape of the marks taken over an area of about a square inch. In the photographs (of specimen 11 below, and specimens 2, 4, 9, and 12 above) the white line on each gives the strike and the arrow the side of dip, the foot-rule giving the scale. Neither the shape nor the orientation of these marks bears any obvious relation to the fine slickenside striations.

The under surface of the bed immediately overlying the marked surface was examined wherever it could be obtained, but always there was a thin film of clay separating the two, and we found no significant feature on this overlying surface. It may be mentioned that one specimen (No. 7) shows a graptolite on the marked surface, but, although not well preserved, it shows no sign of being distorted by movement. Graptolites are rare in the Aberystwyth Grits—this specimen appears to be *Monograptus planus* (Barrande). At one or two other parts of the coast between Aberystwyth and Borth signs of similar marks occur, but these are rare, and such as we have seen are not nearly so striking nor so well displayed as those described above.

The specimens figured and photographed are preserved in the Department of Geology, University College of Wales, Aberystwyth.

The Teschenite Sill of Charlestown, Fife.

By Frederick Walker, Carnegie Teaching Fellow in the University of St. Andrews.

ALMOST all the more important teschenitic intrusions of the Edinburgh district have been examined in some detail at one time or another, but the large sill situated between Dunfermline and Charlestown is a notable exception. In the course of an investigation last autumn, the writer found, however, that, while the normal rock is not specially noteworthy, its segregations present some interesting features, particularly in view of a recent publication by

Dr. G. W. Tyrrell dealing with the age and classification of the analcitic intrusions of Central Scotland.[1]

FIELD CHARACTERS OF THE SILL.

The sill in question is intruded into strata near the bottom of the Carboniferous Limestone Series and has an annular outcrop elongated in an east–west direction and running along or just south of the Dunfermline-Culross branch of the L. & N.E.R. The greatest length of the outcrop is 3½ miles with a maximum breadth to the east of 1½ miles. On the 1 inch geological map (Sheet 32) the intrusion is mapped as "tD" and is referred to as "teschenite" in the corresponding Geol. Survey Memoir.[2] It has recently been remapped on the 6 inch scale by Mr. D. Haldane, of the Geological Survey.

In spite of the large area covered by the outcrop, the natural exposures are masked to a great extent by drift, and it is only in two places that they are at all well seen—in a river section near Pitliver House, and on an upstanding ridge south-east of Leckerstone Farm. There are, however, several quarries from which fresh material may be collected, the most important being at Merryhill, Leckerstone, and at a point about ¾ mile south of Cairneyhill village where the sill abuts to the north on to a large alluvial flat. Merryhill quarry yields a particularly fresh stone which is being worked for road metal at the present time, and it is here that the segregations of the sill may best be studied. Two distinct types of segregation may be observed: (i) a series of parallel veins of light grey rock varying from an inch to a foot in thickness and running practically horizontal at intervals of a few feet, (ii) a number of pink patches irregularly distributed through the dark normal rock. Both sets of segregations show unchilled junctions with the normal rock and are clearly contemporaneous.

The sill has been fractured by several small faults, one of which passes through Merryhill quarry, forming a soft chloritic band in the hard teschenite.

PETROLOGY OF THE NORMAL ROCK.

The normal dark rock of the Charlestown sill shows little variation in the hand specimen beyond a slight increase in coarseness from margin to centre. It is a dark greenish-black non-porphyritic rock of medium grain, and while very compact, shows occasional white zeolitic patches.

Under the microscope it is seen to be a fresh augite-teschenite very similar to several examples from Midlothian and Fife. It strongly resembles the teschenite from Carmelhill quarry in the Dundas sill,[3] and Mr. D. Balsillie has commented to the writer on its likeness to the rock of Lathones.[1] All three rocks are noteworthy for the considerable amounts of alkali-felspar which they contain.

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[1] GEOL. MAG., Vol. LX, 1923, pp. 249–60.

[2] *Geology of the Edinburgh District*, 1910, p. 293.

[3] *Trans. Roy. Soc. Edin.*, vol. liii, part 2, p. 372.

The abundant pale purple pyroxene of the Charlestown teschenite, while sometimes idiomorphic, usually shows a subophitic relationship towards the plagioclase. Dark green serpentinous pseudomorphs after olivine are also abundant and are occasionally penetrated by plagioclase laths. Both the olivine and pyroxene tend to form clusters.

The plagioclase varies from labradorite at the centre to oligoclase at the margin, and is frequently surrounded by a fringe of untwinned albite or soda-orthoclase. Analcite is very common in clear or turbid interstitial patches or replacing plagioclase. Sparse patches of natrolite are of still later crystallization. Accessory minerals include abundant apatite needles, ilmenite, and biotite, which occurs in the immediate vicinity of the iron ore.

Towards the east of the sill there is a diminution in the quantity of analcite accompanied by a more marked ophitic relationship between pyroxene and plagioclase.

PETROLOGY OF THE PINK SEGREGATIONS.

The pale pink segregations are seen under the microscope to be of medium grain and much decomposed. The rock is made up mainly of large plates of simply twinned alkali-felspar some of which appears to be perthitic. Much of this felspar is altered to brown decomposition products. The only other primary constituent present in any quantity is an ophitic green pyroxene whose pleochroism and low extinction angle refer it to aegirine. Patches of quartz, chalcedony, and calcite are abundant and a few crystals of ilmenite, partly altered to leucoxene, may be observed.

PETROLOGY OF THE GREY VEINS.

The rock of the grey veins is seen in the hand specimen to be much fresher than that of the pink segregations. It is of medium and even grain, the black ferromagnesian minerals standing out clearly from a background of white felspar. Microscopic examination shows that it is made up essentially of large plates of alkali-felspar and quite subordinate plagioclase which generally bear a subophitic relationship to elongated crystals of pale purple titanaugite. This pyroxene occurs occasionally in idiomorphic prisms and is often fringed with bright green aegirine-augite. Other ferromagnesian constituents are a few serpentinous pseudomorphs probably after olivine, and small ragged crystals of aegirine and a blue amphibole. Zeolitic patches are common in the rock, usually consisting of turbid analcite, but thomsonite and natrolite have also been observed. Accessory minerals include apatite and titaniferous magnetite. Nepheline was not recorded in any of the writer's sections.

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[1] GEOL. MAG., Vol. LIX, 1922, p. 450.

Mr. Balsillie, having very kindly made an optical examination of the felspar and amphibole, reports that the former is probably orthoclase with a considerable proportion of soda in the molecule, as its extinction is wavy and it has a refractive index less than 1·526 (chlorobenzene). He also records albite as a rare constituent. The amphibole he regards as a member of the riebeckite-hastingsite-arfvedsonite series, but states that its properties are so variable that exact identification is impracticable. An analysis of the rock has been made by Mr. W. H. Herdsman and is quoted below.

CONCLUSIONS.

In a recent paper of great interest[1] Dr. Tyrrell has divided the analcite-bearing rocks of Scotland into two suites which he considers to be petrographically distinct—the teschenite suite and the crinanite suite. He suggests, furthermore, a late Carboniferous or Permian age for the whole teschenite suite and a still later age for the first of the crinanites.

Few will care to gainsay his conclusions with regard to the West of Scotland, but with the analcitic rocks of the East the case is quite different. Here we have a petrographic resemblance with the undoubted Permo-Carboniferous examples of Ayrshire arrayed in unequal contest against a weighty mass of field evidence pointing to a Lower Carboniferous age. It is true, as Dr. Tyrrell points out, that certain teschenitic sills are intrusive into the lower part of the Carboniferous Limestone Series, but a glance at a geological map shows that, while such sills occur abundantly on either side of the Midlothian coal basin, they are completely absent from both the Millstone Grit and Coal Measures of that area, as indeed are all igneous rocks other than some east–west dykes of quartz-dolerite. Passing across the Forth we find the same true of the East Fife coal basin, while the recent work of Mr. Balsillie,[2] has thrown grave doubts on the Permian age of most of the volcanic vents of East Fife and their associated intrusions.

The writer holds, moreover, that Dr. Tyrrell has over-emphasized the differences between the teschenite and crinanite suites. Teschenite is considered by him to yield lugarite as its acid differentiate, while crinanite yields analcite-syenite.[3] The Charlestown rock, however, which is an undoubted teschenite, yields an equally undoubted analcite-syenite as its acid differentiate instead of lugarite, the petrographic and chemical resemblance between the grey veins of Merryhill Quarry and the type analcite-syenite of Howford Bridge[4] being very striking.

The basaltic lavas of the Calciferous Sandstone Series contain flows of Hillhouse type which appear to be closely related to the more basic teschenites, while many flows of Jedburgh type show a strong resemblance in texture and mineral composition to olivine-dolerites of the crinanite suite.[1] Mr. E. B. Bailey again has noted the strong petrological affinity of the Lennoxtown essexite to neighbouring lavas of Craiglockhart type and of Calciferous Sandstone age.[2] That the early Carboniferous magma could and did produce actual crinanitic sills is shown by the occurrence of such an intrusion at West Gordon near Kelso, the rock being indistinguishable from many crinanites of the West of Scotland, and having, moreover, a strong resemblance to some of the local basalts. It will be recollected that igneous activity in the Kelso district commenced in Old Red Sandstone times and there is no reason to believe that it persisted into the Upper Carboniferous.

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[1] Loc. cit.

[2] GEOL. MAG., Vol. LX, 1923, pp. 530–42.

[3] Loc. cit., pp. 250, 251.

[4] GEOL. MAG., 1912, p. 71.

The balance of probability seems, therefore, to rest in favour of a Lower Carboniferous age for most of the analcitic igneous rocks of the East of Scotland.

ACKNOWLEDGMENTS.

The writer desires to express his warmest thanks to Mr. D. Balsillie, of the Royal Scottish Museum, for his aid in identifying the amphibole and felspar of the Merryhill segregation veins and to Mr. D. Haldane, of the Geological Survey, for much useful information with regard to exposures.

ANALYSIS.

	A.	B.
SiO_2	55·27	56·44
TiO_2	·80	1·16
Al_2O_3	17·86	15·54
Fe_2O_3	1·95	3·27
FeO	4·91	3·67
MnO	trace	n.d.
MgO	2·34	1·73
CaO	4·08	4·16
Na_2O	5·24	5·81
K_2O	3·39	4·27
H_2O	·80	·44
H_2O	3·15	2·06
CO_2	nil	·97
P_2O_5	·27	·83
S	·06	—
	100·12	100·35

A. Grey vein, Merryhill Quarry, Charlestown, Fife. Analyst, W. H. Herdsman.

B. Analcite-syenite, Howford Bridge, Mauchline. Analyst, M. Dittrich. Geol. Mag., 1912, p. 72.

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[1] Compare *Edinburgh Memoir*, pl. xi, fig. 4, with Geol. Mag., 1923, Pl. XI, Fig. 4.

[2] *Mem. Geol. Surv. Scotland, Glasgow District*, 1911, p. 113.

Note on the Occurrence of Thrust-Faulting in Western Newfoundland.

By Charles C. Mook.

During the summer of 1918 a party under the direction of Mr. Hamlin Brooks Hatch carried on field studies in a section of the property of the Reid-Newfoundland Company in Western Newfoundland. A number of features of general scientific interest were noted, among which was faulting of the Appalachian type. The writer is indebted to Mr. Hatch for permission to publish this phase of the results of the latter's investigations.

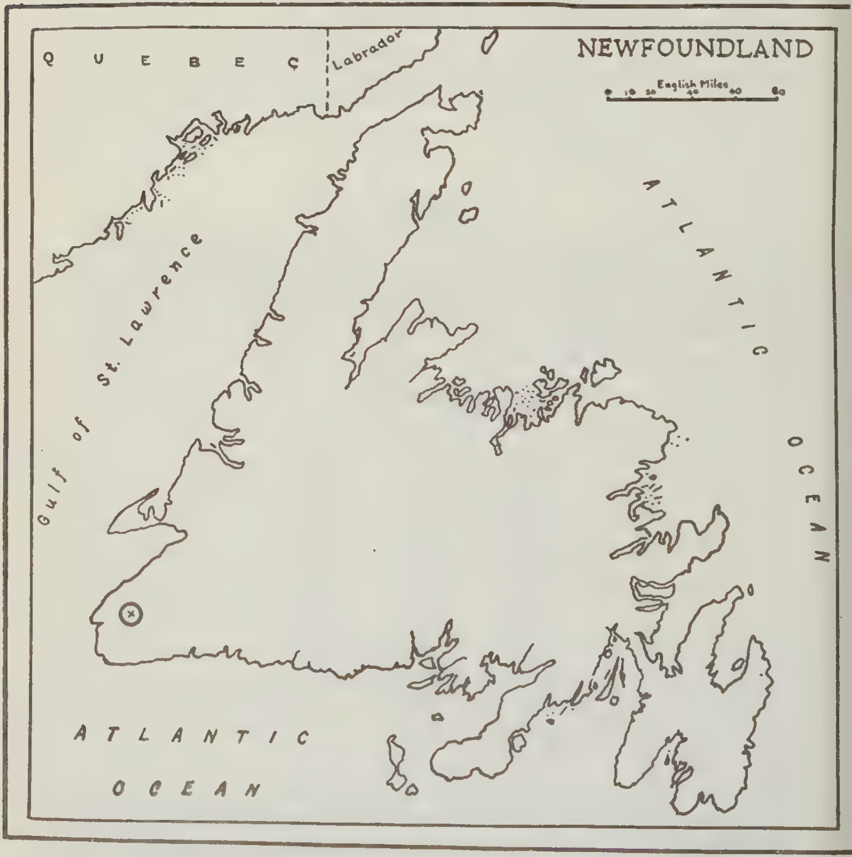

Fig. 1.—Map of Newfoundland, showing the position of the locality described.

The locality in which the studies of faulting were made is near

South Branch, about forty miles north of Port-au-Basque. The rocks of this region consist of complex Archean crystallines, schists, probably of Algonkian age, early Palaeozoic sediments of various sorts, and later coal-bearing sediments probably of Pennsylvanian age. The thrust-fault noted lies between these later sediments and the older rocks.

The crystalline rocks and older sediments outcrop in a mountainous area several miles to the east of the railroad. West of this area is a lower belt occupied by the later sedimentary series. The western flank of the mountains consists of an eroded fault-line cliff. A small stream has excavated a narrow shallow valley at the foot of the mountains at the contact of the older rocks and the younger sediments.

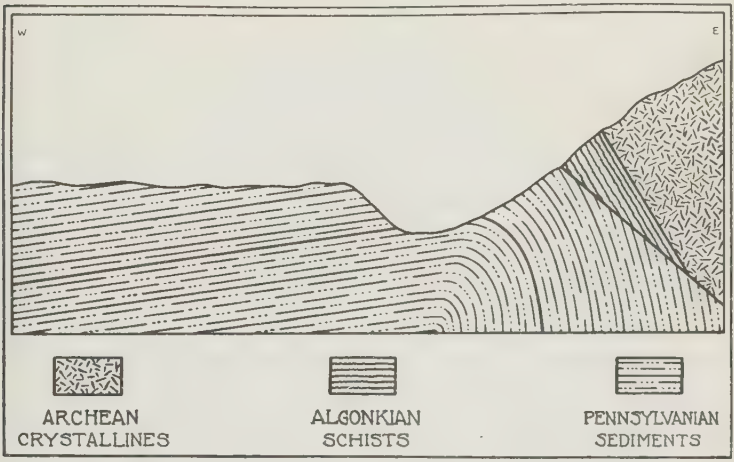

FIG. 2.—Section across the South Branch district.

The structure of the later sediments west of the fault is anticlinal, with a gentle dip on the west limb and a steep dip to the east beneath the fault-plane. The inclination of the fault-plane is less than that of the eastern limb of the anticline. The older rocks east of the fault lie in reversed order, Palaeozoic series first, then Algonkian series and finally the ancient crystallines. There are thus three structural elements to be noted at the contact of the later sediments with the older terranes ; first, the anticline in the earlier sediments themselves ; second, the thrust fault with the older rocks lying upon the coal-bearing series ; third, the reversed character of the older rocks.

The relation of the overturned series to the fault recalls similar structures in the Appalachians farther southwestward. The trend of the major dislocations in Central and Western Newfoundland is in approximate accord with that of the Appalachian folding and faulting. The fact that Pennsylvanian beds are involved in the movements limits the age of the faulting to late Pennsylvanian at the very earliest.

These facts taken together, the nature of the combined overturn and thrust faulting of the Appalachian type, the correspondence in trend of this fault and other major dislocations in Western Newfoundland with the axes of Appalachian folding, and the fact that beds of Pennsylvanian age are involved in the folding, suggest that this faulting took place in Permian time and may be considered as part of the general system of Appalachian movements.

A Note on the Youngest Beds of the Southern Province of Nigeria.

By John Parkinson, Sc.D., F.G.S.

THE Colonial Office Report on the work of the Mineral Survey of Southern Nigeria for 1905–6 gave a few details on the occurrence of bitumen in Ijebu and a paper by Mr. R. Bullen Newton published in the *Ann. and Mag. of Nat. Hist.*, Section 8, VIII, pp. 193–208, described some mollusca which fortunately were preserved in one or two of the shallow boreholes put down to afford information on the beds then named the "Ijebu Series". No details of the beds passed through were, however, published, and the following note is intended to supplement the Report mentioned.

A number of shallow wells were drilled by the Survey in the Ijebu sub-province and from the detailed logs of these the following is selected as typical :—

	ft.	in.
Red clay	20	6
Yellow clay with white streaks . . .	2	3
Pale grey clay	3	9
Dark grey clay with a few lamellibranchs and rare gasteropods		6
Dark grey clay	5	0
Second shell bed[1]	2	0
Stiff greyish-black clay, becoming slightly bituminous in lower half with shells at base	5	6
Bituminous clayey sands with some shells. .	3	9
Dark chocolate-brown clay, poor in bitumen .	2	1
Tenacious, grey, non-bituminous clay, not sandy	4	0
Bituminous clayey sands	7	9

The essentially argillaceous nature of the beds will be noticed in distinction to the essentially arenaceous nature of those passed through to the east at Saforagbo and Jamoa, summarized logs of which are given later.

Shallow pits put down at Epe for the purpose of investigating the superficial beds, found at the top of the low hill on which the

[1] The word "shell" is used in the geological, not in the driller's sense.

station stands 48 feet of angular quartz sand before the crystalline rocks were reached.

A second pit half-way down the hill found no crystalline rocks at 45 feet, but passed through a bed, 3 ft. thick, of iron-stained clay which may have resulted from the disintegration of a schist. There is thus a considerable thickness of talus resulting from the decomposition of the crystalline rocks, whilst the Ijebu Series, if it occurs, must do so beneath the waters of the lagoon.

Marked bituminous impregnations occur in the Ijebu Erimo Hill about 22 miles N.E. of Epe—in what are believed to be the higher beds, termed the Benin Sands, and on the edge of the floor of crystalline rocks which constitutes by far the largest portion of the Southern Province.

Immediately to the north of Ijebu Erimo lies the village of Lumawgo, and to the east of the main outcrops of the bitumen beds, a section of which has just been given.

The granite of Lumawgo, bounded on either side by extensive alluvial flats, is of medium to rather coarse grain, cut by pegmatite veins and showing a feeble foliation.

A pit on the top of the hill gave at least 20 feet of decomposed rock, containing lumps of kaolinized felspar, angular and subangular grains of quartz and much muscovite.

Clearly there has been no rearrangement by water. Two miles W. of Lumawgo, 74 feet of the red sandy clay of the Benin Sands was found, the hand-boring gear employed being unfortunately incapable of going much deeper.

Concentrates showed small red garnets.

Local impregnations by bitumen of the Benin Sands occur at the base of Ijebu Erimo Hill and on the Hill itself, the latter being investigated by means of cuts and headings. The riverside section showed red clayey sand as surface soil, underlain by false-bedded white sand, the quartz grains coarse and very angular. A thin and local bed of red clayey sand separated this from sand impregnated by bitumen in varying degrees; the base was not seen, and the total thickness exposed was about 15 feet.

The local nature of these impregnations is shown by a bore put down on swampy soil at the base of the hill. After 50 feet of surface soil, hill wash, etc., 2 feet of grey micaceous clay was passed through, sandy above with clots of decomposed felspar, lower down small pink garnets and much biotite. No doubt can exist that this is a greatly weathered member of the crystalline series.

The levels run in the clayey sand of the hill itself showed an interesting number of veins of bitumen, strongly recalling thin igneous dykes in appearance and accompanied by a certain amount of local lateral impregnation of the more ordinary type. Some of the larger veins were 5 inches across, and the bitumen was sufficiently liquid at the temperature (about 92°) to ooze from the cracks as exposed and drip on the floor of the level.

It is concluded that a part of the bituminous series is intercalated between the crystalline floor of gneiss and schist and the Benin Sands —the pressure having been clearly sufficient to force petroleum up into fissures formed in the upper group, which is clearly not the series of origin.

A sandy alluvial terrace of the river shows a grey sandy clay with pebbles of quartz, some of which are over an inch long and often well rounded, grains of decomposed felspar and muscovite, with small plates of quartz, presumably derived from a micro-pegmatite. The extraordinary sameness in the angularity of the quartz grains and general appearance of the later beds denotes rapid denudation and deposition from a surface of crystalline rocks prepared by long continued disintegration in situ. The fine grey micaceous clays common locally are doubtless derived from rather basic schists. Whether this period of rapid deposition corresponds with the pluvial period so marked elsewhere in Equatorial Africa is a point of some interest.[1]

Saforagbo Well.—In this connexion a brief summary of the beds passed through in a bore put down near the village of Saforagbo, 65 miles S.E. of Lumawgo (Ondo) is interesting as giving an insight into the nature of the alluvium and older beds enclosing the plexus of creeks and rivers extending from Lagos to the Niger and beyond eastwards. For permission to publish I am indebted to the courtesy of the British Colonial Petroleum Co. Red sandy clays—66 ft. thick—form the surface soil and are followed by an alternating group of variously coloured clays and coarse sands containing quartz fragments up to 5–7 mm. across and small quartz pebbles.

To 130 feet the same type of deposit continues, red-brown, grey and white clayey sands with quartz-grains and pebbles up to 22 mm. as before, clay with streaks of sand being especially noticeable from 126 to 129 feet.

From 130 to 200 feet, red clays to sandy, with clay (kaolin) nodules and thin clays occur. The beds constantly vary in minor particulars of colour (grey to terracotta) and consistency. At about 171 feet quartz grains and pebbles up to 20 mm. long were found.

About 220 feet some change may be indicated by the appearance of ironstone nodules, kaolin clays and iron pyrites, but the general type of the beds did not greatly differ until at 231 feet a shale or very laminated clay occurred crowded with plant fragments. Although samples were most carefully examined, no mollusca were found.

A similar rock was repeated from 235 to 248 feet; a black, carbonaceous shale, crowded with plant remains, laminated and sandy, followed at 250 feet by medium to coarse grey sand with very irregular and pitted quartz grains.

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[1] In regard to the south boundary of the crystalline rocks a fine biotite-granite occurs about 7 miles south of Odigbo, followed in a north direction by banded gneiss with occasional garnets and pegmatites. Near the Owanna River, west of Onishave, are porphyritic and grey micaceous granites with others approaching syenites in composition.

To 415 feet black clays and grey to black sands with fragments of fossil wood (347 feet) occur: the sands greatly predominate from 295 feet onwards, the larger grains being about 6 mm. across.

At 415 feet a few well-rounded quartz pebbles are recorded, the largest 23 mm. long, and followed by shale, black, sandy and with plant remains at 420 feet, coarse pebbles occurring again at 420½ feet. From here to 459 feet, when the log ends, black sands and clays occur. In the first 250 feet of this well small gas-shows were common.

Another bore put down at Jamoa near Koko and below Sapele (about 23 miles E.S.E. of that at Saforogbo) showed that the surface soil consists of soft bluish clays and red sandy clay followed by a similar group of clayey sands and clays, mottled grey, yellow or red, and somewhat micaceous, containing frequently pebbles about 10 mm. across. These continue to nearly 400 feet.

In some cases the angularity of the quartz grains may be due to fracture by the bit along early lines of weakness. A dark grey clay with many fragments of plants but not so carbonaceous in appearance as the shale from the Saforogbo well was passed through from 230–5 feet; soft grey shales with plant fragments also occurred from 330–50 feet, underlain by 30 ft. of grey sands with shale partings.

In this well the change to the lower series would seem to take place about 230 feet. These beds, it is suggested, are members of the Lignite Series, which by analogy with the district near Asaba (west bank of the Niger) would be of Eocene age.

In the south, however, marine beds belonging to the Early Tertiary also occur. (See Bullen Newton, ibid.) In the Jamoa log sands predominate, with angular grains as before, and the series passed through in the two bores are no doubt identical.

All these beds have been clearly derived from an acid series of crystalline rocks, their varying composition indicating corresponding differences in the velocity of the current of deposition, the pitted surfaces and sharp outlines of the quartz grains (making all allowances for fracture by the bit) showing that the distance from the source of supply to that of deposition was short. It is inferred that the crystalline rocks were weathered to a considerable depth before deposition commenced.

A Deposit of Shell-bearing Tufa near Lydney, Gloucestershire.

By A. W. Coysh.

THE tufa that forms the subject of these notes occurs on the eastern side of Park Brook in Upper Old Park Wood, 2 miles north-west of Lydney (6 in. O.S. Sheet, 47 N.W. Glos.).

The deposit lies close to the stream and occupies a triangular area measuring roughly 90 by 100 yards and has a maximum thickness of 12 feet. The base of the triangle runs parallel with and near the edge of the stream, tapering away up the hill. It is in a much weathered condition and is covered in places with moss and has weathered in others to a black or dark red soil 1 foot in thickness. On this a number of large trees have taken root.

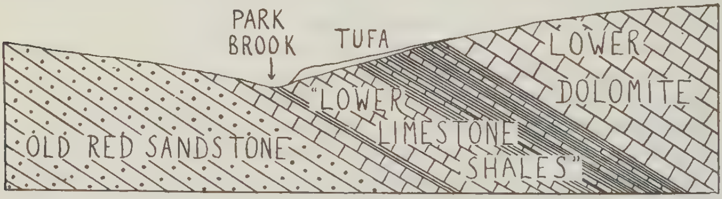

Fig. 1.—Diagrammatic section across Western Valley showing the relation of the Tufa to underlying strata. Length of section = 300 yards.

The tufa has been deposited by water emerging near the base of the Lower Dolomite and flowing into the Park Brook ; but no trace of a stream is now seen.

The deposit is a cream-coloured compact rock, consisting almost entirely of calcium carbonate—92·3 per cent ; 3·7 per cent of magnesium carbonate is present, 1·65 per cent of insoluble residue, and traces of iron and alumina. The dolomite from which it has been derived contains 39·1 per cent of $MgCO_3$ and 1·46 per cent of insoluble residue.[1]

Several fragments of haematite were found in the tufa, evidently washed down by water, as this ore is of common occurrence in the Carboniferous rocks of the district.

An insoluble residue from the deposit was found to consist mainly of detrital quartz, no doubt derived in part from the limestone and in part wind-borne from the adjoining Old Red Sandstone. (See section.)

Careful collecting yielded the following land shells :—

Vitrea crystallina (Müll.).	One example.
**Polita cellaria* (Müll.).	Three examples.

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[1] T. F. Sibly, " The Haematites of the Forest of Dean " : *Mem. Geol. Surv.*, Appendix II, p. 86, No. III. The analysis quoted gives the amount of magnesium in terms of the oxide.

*_Polita nitidula_ (Drap.).	Two examples.
Polita radiatula (Ald.).	One example.
*_Goniodiscus rotundatus_ (Müll.).	Very common.
Helicigona lapicida (Linn.).	One example.
Arianta arbustorum (Linn.).	Two examples.
*_Helix nemoralis_ (Linn.).	Three examples.
Helix hortensis (Müll.).	One example.
Carychium minimum (Müll.).	Common.
Cochlicopa lubrica (Müll.).	Three examples.
*_Clausilia laminata_ (Mont.).	One example.
Vertigo pusilla (Müll.).	One example.

All the above species are still indigenous to the district. *Goniodiscus rotundatus* (Müll.) and *Carychium minimum* (Müll.) are abundant, as will be seen from the above list.

The species marked with an asterisk have been found in Merlin's Cave near Symonds Yat,[1] about 8 miles north of the present locality. There they were associated with jaws of lemming and may be regarded as of Pleistocene age.

All except the two small forms—*Carychium minimum* and *Vertigo pusilla*—have been recorded from Aveline's Hole, Burrington, where they have been referred to a late Pleistocene age.[2]

It is difficult to assign a definite age to the tufa deposit as all the species recorded have a relatively large range in time.

They may be said to denote damp conditions and are almost certainly of Holocene age.

I am greatly indebted to Mr. A. S. Kennard, F.L.S., for his kind help in the identification of the mollusca, to Mr. R. H. Coysh, M.Sc., A.I.C., for the chemical analysis, and to Mr. James Lauder, agent for the Lydney Park Estate, for granting me ready permission of access to the deposit.

The Shimbar Valley Landslip Dam, Bakhtiari Country, South Persia.

By H. G. Busk, M.A., F.G.S.

TRAVELLERS in Persia rarely diverge far from the beaten track between town and town, and there are areas in the South Persian mountains, hundreds of square miles in extent, in which there is no record of penetration by Europeans. Needless to say, such unexplored regions are frequently treasure houses of geological interest of sometimes the rarest and least expected kind.

It was during an examination of one of these little visited parts which lies under the 12,000 ft. range of Kuh Kinuh, some 60 miles north-east of the Maidan-i-Naftun Oilfield, and 120 miles in the same direction from Ahwaz, that the author and his companions, Messrs. J. Nason-Jones, B.Sc., and W. H. Dowling, B.A., crossed the Shimbar River at a spot, where, from being a strongly degrading stream, it apparently became an equally obviously strongly aggrading one. Such a sudden change of grade seemed to suggest a glaciated rock basin, and, as no signs of glaciation had been so far observed in this part of Persia, it was resolved if possible to cross the valley a few miles lower down on the return journey. The only other possible explanation, which occurred to us at the time, was that the river lower down had become constricted into a crack, too narrow to receive its flood waters, for instances of such canyons with broad flood plains above them are not wanting in this part of Persia.

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[1] *Proc. Univ. of Bristol Speleo. Soc.*, vol. ii, No. 2, p. 162.

[2] Ibid., vol. ii, No. 1, pp. 32–3.

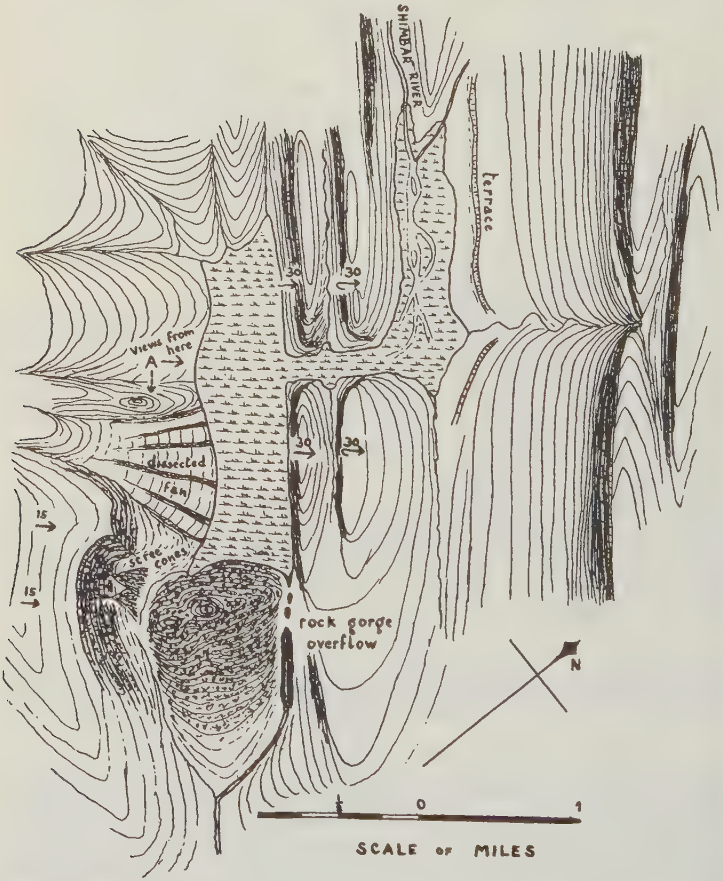

Fig. 1.—Sketch-map drawn roughly by eye of Shimbar Valley landslip dam.

On the return journey, crossing lower down the valley, we came upon a phenomenon, which with the exception of things volcanic, seemed to be as near a geological catastrophe as any of us had ever seen or read about. The aggraded valley was barred at its lower end by an enormous mass of broken rock, which had crashed bodily from a very obvious and still ugly-looking scar on the south-west side of the valley.

The only other record of a visit, we found afterwards, is one by that intrepid explorer, Sir Henry Layard, in the early nineteenth century, who recognized in part the geological significance of what he saw.

We had ourselves only half a day to spend on exploration, and the appended map is only a sketch by eye, very roughly to scale ; it is obvious that for anyone, who has the time and money to spend on a careful examination, the place presents many points of unique interest, especially in the study of comparative time-scales.

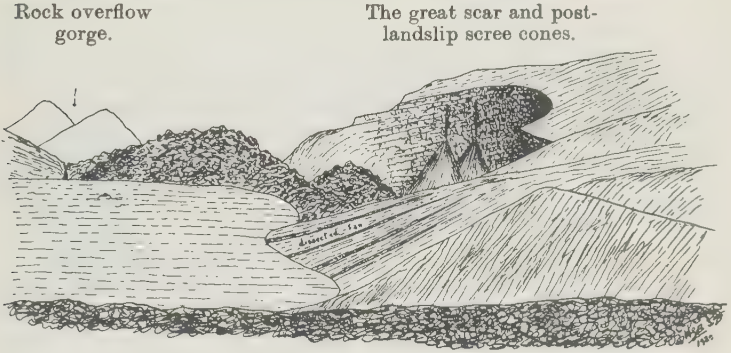
Rock overflow gorge.
The great scar and post-landslip scree cones.
dissected fan

FIG. 2.—View from point *A* (Fig. 1) looking S.E. of the landslip barrier and the great scar, from which it came. From a sketch in the field.

Above the "landslip dam", as we may call it, the aggraded valley, which is some 3½ miles long, excluding a small branch to the north-west, is flooded in the spring time when the snows come down, and becomes a shallow lake, nowhere deep enough, however, to kill the low bush vegetation, which is in the dry season the haunt of great herds of wild pig.

Below the dam the valley assumes its normal V-shaped section.

Here are a few rough figures :—

Height of top of dam to lake floor . .	800 ft.
Height of top of dam to valley floor below .	1,500 ft.
Consequently thickness of the alluvium at the lower end of the lake is about	500–600 ft.
Transverse width of dam	2,500 ft.
Rough estimate of its cubical content . .	10 thousand million cubic feet or about 600 million tons.

Can any of man's engineering feats compare with this?

The upper part of the aggraded valley, after running for a mile south-east along the strike of the rocks, cuts transversely across a recumbent syncline of limestone, whose limbs dip about 30 degrees north-west; the valley then continues its way along the strike, with the recumbent syncline on the north-east, and an extensive dip slope (15 degrees) on the south-west. It is part of this dip slope, which is composed of about 1,500 feet of Asmari limestone (Lower Miocene), which has given way and slid over the Eocene clays that lie below it. There was here, moreover, no gentle creep, but a sudden crash, all over in the course of a few minutes, for the impetus of the movement has shot the rock mass into a heap in the bottom of the valley, in such a manner that there is a gap between the scar and the slipped mass of over a quarter of a mile. What the reverberation and concussion of such a cataclysm can have been we can barely imagine!

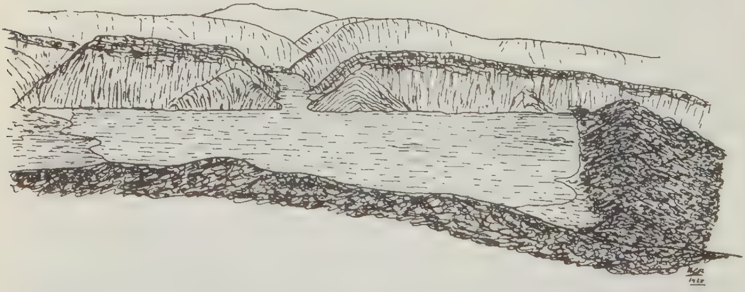

FIG. 3.—View from point *A* (Fig. 1) looking N.E. From a sketch in the field.

The surface of the dam is most difficult to climb over, as it is composed of a disordered mass of enormous angular boulders up to 30 ft. high, each constituting a real rock climb, and, in the shaded crannies between them, ferns and mosses, which are so rare in this arid part of Persia, abound. The great scar, from which the material has fallen, still overhangs the gap very ominously, and during a wet winter, such as that which we were then experiencing (1924–5), the author and his friends would have hesitated to pitch their camp, or indeed to linger long, under it.

Immediately below the cliff there is a post-landslip scree, arranged as two interfering cones, which issue from two corresponding gullies, and the rate of accumulation of the material in this scree would clearly measure exactly the age of the dam. The screes are composed of small irregular fragments and their accumulation seems to be due as much as anything to frost action working on the cliff.

Although even during dry weather a fair volume of water enters the alluvial plain at its upper end (the ford is knee-deep and 100 ft.

across), this soaks in, and must eventually seep through the dam, but we had no time to examine the down-stream side of the dam for springs. What has, however, been the great factor in the preservation of the life of the dam is that the flood overflow water passes over a rock barrier. This rock overflow channel is incised to about 40 ft. at its upper end, and probably many hundreds of feet further down. It is a canyon with vertical sides, and is roofed over by the solid rock for a considerable distance of its total length. Here again the depth of the canyon constitutes a time scale, for the time taken to cut the gorge must equal the time taken to accumulate the 700 odd feet of alluvium, which must again be equal to the age of the dam, plus the time since which the alluvium has reached the lip of the rock incisement. This would seem to have just happened, for the alluvium is exactly level with the lip, which is, as far as we could make out, still a rock barrier, that is there has been no aggradation in the canyon nor cutting back into the alluvium.

There are one or two features of the valley which we were unable to explain in the time, namely a number of raised terraces at the upper end of the old lake to the north-east of the valley, and a well-marked alluvial cone at the lower end on the south-east side.

Does the height of these terraces tally with the height of the rock lip before it was incised, and does the building of the now dissected alluvial fan belong to the same period, i.e. immediately after the landslip ?

These, with the other problems that we have outlined, relating to the comparative rates of accumulation of the alluvium and the cliff screes, with the rate of incisement of the overflow channel and the date of the landslip, or rather " land crash ", we must leave to future examination, together with excavations into the alluvium, which might reveal interesting remains, and which one day will no doubt be made.

Eocene Echinoids from N.W. Peru.

By A. G. Brighton, M.A., F.G.S., Sedgwick Museum, Cambridge.

(PLATE XXVI.)

THE fossils to be described were collected by Messrs. C. Barrington Brown and R. A. Baldry, to whom I am indebted both for the opportunity of examining these forms and for the details given below of their horizon and locality, for which they are entirely responsible. The collection has been presented by them to the Sedgwick Museum, Cambridge.

Part I. The Atascadero Limestone.

The material from this horizon includes 147 specimens, referable to seven species. One species, represented by six specimens, belongs to the family Spatangidae, and two other species are represented by one example each; the state of preservation of these specimens does not allow of generic determination. A valuable series of 125 examples of *Oligopygus ovumserpentis* (Guppy) provides ample material for founding a new variety and discussing its range of variation. The other genera represented are *Rhynchopygus* and *Echinolampas*. All the specimens are from the same horizon and locality, and are preserved in a hard, brown, sandy foraminiferal limestone.

Mr. Barrington Brown writes: "This limestone, for which we propose the name Atascadero Limestone, is typically developed in the neighbourhood of the hamlet Atascadero near the Pariñas Valley some 20 miles east of Capo Blanco. Here the Tertiary strata have their eastward termination, resting on the ancient rocks of the Amotape Mountains. Near Atascadero, the limestone is underlain by 250 feet of green sandstones with *Nautilus* and other fossils, and a conglomerate and boulder bed, 150 feet thick, the base of the Tertiary beds. Beneath are Carboniferous rocks. There is an enormous overlap of successive Tertiary beds as the Amotape Mountains are approached from the coast; the limestone is at a horizon several hundred feet up in the Lobitos Formation as defined by Bosworth (1922, *The Geology and Palaeontology of N.W. Peru*, 8vo, London), all the Negritos Formation having disappeared by overlap by the time the base of the Tertiaries is reached in this area.

"The Atascadero Limestone varies in thickness from 40 to about 10 feet. In its thinnest development it is almost entirely a conglomerate with a calcareous foraminiferal matrix. Elsewhere this conglomerate forms only the basal part of the limestone, and consists of well-rounded porphyritic volcanic rocks derived from the Andes, and not locally from the Amotape Mountains. Fossils are abundant; several species of foraminifera, echinoidea, gasteropoda and lamellibranchia are found. The mass of the limestone is formed of small nodules (? *Lithothamnium*), which, with *Oligopygus* and *Echinolampas*, weather out on the hill-slopes as a coarse gravel. In places a bed of 3 or 4 feet is composed entirely of foraminifera."

Genus Oligopygus de Loriol, 1887.

O. ovumserpentis (Guppy).

1866. *Echinolampas ovum-serpentis* Guppy, *Q.J.G.S.*, xxii, p. 300, pl. xix, figs. 4–6.
1875. *E. ovum serpentis* Guppy, Cotteau, *Kongl. Svenska Vet.-Akad. Handl.*, xiii, pp. 20–1, pl. iii, figs. 13–21.
1897. *E. ovum serpentis* Guppy, Cotteau, *Bol. Com. Mapa Geol. España*, xxii, pp. 62–3, pl. xvi, figs. 5–9.
1911. *Oligopygus ovum serpentis* (Guppy), Stefanini, *Revista Ital. Palaeont.*, xvii, pp. 88–90.
1915. *O. ovum-serpentis* (Guppy), Clark and Twitchell, *U.S. Geol. Surv. Mon.*, liv, pp. 167–8, 170.
1922. *Echinolampas ovumserpentis* Guppy, Jackson, *Carnegie Inst. Washington Publ.*, No. 306, pp. 60–3, pl. x, figs. 4–5.

1924. "*Echinolampas*" *ovumserpentis* Guppy, Hawkins, Geol. Mag., LXI, p. 318.

O. ovumserpentis var. *baldryi* nov.

Pl. XXVI, Figs. *e–h*; Text-figs. 1 *a–g*.[1]

Diagnosis.—This variety is characterized by its small size and its narrow interporiferous areas; the ratio between the width of the interporiferous area and that of the adjacent pore-field at the line of greatest width of the petal being usually one or less than one.

Material.—The 125 specimens, all more or less weathered, belonging to this species, allow the variation to be studied. Since the ambulacral plating-structure of *Oligopygus* has never been described (for which reason among others this form is referred to *Oligopygus* with some hesitation), the species is dealt with in detail.

Description.—The dimensions in mm. of twelve of the specimens are :—

Specimen.	*Length* (*L*).	*Width* (*W*).	100 *W*/*L*.	*Height* (*H*).	100 *H*/*L*.
2	27·2	22·6	83·1	13·2	48·5
8	24·2	20·0	82·6	12·2	50·4
10	23·6	20·1	85·2	8·8	37·3
24	22·2	19·3	86·9	9·5	43·2
28	21·4	19·1	89·2	11·3	52·8
38	20·0	17·4	87·0	9·8	49·0
48	19·2	15·6	81·2	11·1	57·8
56	18·2	16·0	87·9	10·1	55·5
68	17·1	13·2	77·2	8·1	47·4
88	15·1	13·1	86·8	7·3	48·3
97	13·5	11·3	83·7	6·8	50·4
114	9·9	8·2	82·8	4·5	45·5

The length varies from 27·3 mm. (Specimen No. 1, a worn example) to 9·9 mm. (No. 114); the majority (81 per cent) of the values for the lengths are evenly distributed between 23·6 and 12·5 mm., Average length of 112 specimens, 18·3 mm.

The width varies from 89·2 per cent of the length (No. 28) to 77·2 per cent (No. 68). Average width of 109 specimens, 15·4 mm. or 83·7 per cent of their average length.

The height varies from 57·8 per cent of the length (No. 48) to 37·3 per cent (No. 10). Average height of 108 specimens, 8·7 mm., or 47·7 per cent of their average length. The majority of the values for 100 H/L fall between 42 and 53 per cent.

Test usually inflated. Adapical surface convex, sometimes slightly flattened; highest point central or slightly eccentric posteriorly, and coinciding with the position of the apical disc; petals and apical disc inflated, adradial sutures of petals sometimes depressed. Ambitus approximately midway between the adapical and adoral surfaces. Ambital outline inflated, oval, with the posterior region somewhat truncated; constricted usually by the pore-fields, and

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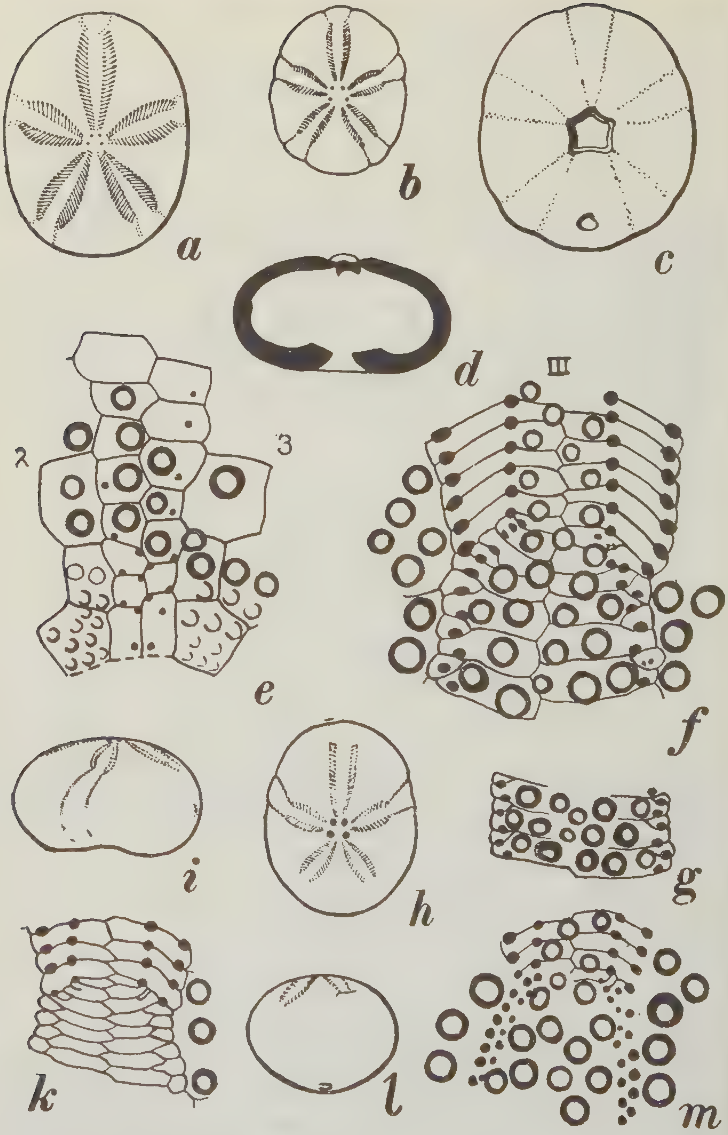
[1] Further illustrations of this form will be given in the sequel to this paper.



E. M. Talbot and A. G. B., del.

FIG. 1*a–g*, *Oligopygus ovumserpentis* (Guppy) var. *baldryi* nov. *a, b*, adapical view, showing pore-fields; *a*, specimen No. 68; *b*, No. 110. *c*, adoral view, showing pore-fields, margin of peristomial depression, peristome, and periproct; No. 67. *d*, transverse section passing through apical disc; showing thickness of test and curvature of corona near the peristome; No. 115.

occasionally by the interradial tracts; line of greatest width eccentric, usually anteriorly (occasionally anterior to the ambital ends of petals II and IV), but sometimes posteriorly (immediately anterior to the ambital ends of petals I and V). Adoral surface concave in antero-posterior section, convex in transverse section; pore-fields often slightly sunken. In the immediate neighbourhood of the peristome, the corona slopes sharply inwards (Text-fig. 1*d*), producing a subpentagonal depression of the same shape as, but only slightly larger than, the peristome (Text-fig. 1*c*); the ambulacra are sunken both within this depression and just outside it.

Peristome central, deeply sunken, irregularly pentagonal (the two sides bordering interambulacra 2 and 3 are nearly in alignment producing a subquadrate appearance); usually slightly elongated transversely.

Periproct small, subcircular, usually slightly elongated transversely, inframarginal, varying in position.

Apical disc small, with four genital pores; madreporic pores occupy the whole of the space between the genital pores and extend between and slightly beyond ocular pores I and V.

Petals open, long, extending more than two-thirds of the way towards the ambitus; petal III the largest, petals II and IV the smallest. Width of petals varying between one-half and one-third of the length, petal III relatively the narrowest. In each petal the two inner rows of pores usually steadily diverge from the apical disc, but occasionally they converge slightly at the ambital end. At the line of maximum width of the petal, the ratio of the width of each pore-field to the interporiferous area is usually one, sometimes more than one (as is common in the larger specimens), but occasionally reaches one-half in the smallest specimens. In the comparatively few unweathered specimens it is seen that the inner pore is circular, the outer slightly larger and a little elongated.

The plating-structure and arrangement of the pore-pairs are best understood from the diagrams (Text-figs. 1*e*–*g*). The end of the petal partially embraces several occluded and included plates, each exhibiting a depression within which on some examples is seen a minute pore-pair. Similar depressions, crowded together and arranged more or less biserially, extend towards the peristome; they are

e, plating-structure and ornamentation of the adoral end of ambulacrum III, with the adjacent interambulacra; tubercles represented by circles, tubercles with diminished scrobicules by arcs; No. 116. *f*, plating-structure and ornamentation of the region round the ambital end of petal III; the black ovals outside the petals represent depressions, two of which are seen each to include a pore-pair; No. 68. *g*, plating-structure and ornamentation of the ambital region of ambulacrum III; No. 68.

Figs. *h*–*m*.—*Oligopygus* sp. *h*, adapical view. *i*, lateral view from left side. *l*, posterior view (the end of petal I is missing). *k*, *m*, plating structure and ornamentation of ambital ends of petals. *k*, amb. II, very weathered. *m*, amb. IV, unweathered.

Figs. *a*–*d*, *h*, *i*, *l*, × 2; Figs. *e*, *f*, *k*, *m*, × 5. Magnifications approximate.

borne on demiplates alternating with primaries, which, however, may be occluded, especially near the petal. These primary plates are very low, and increase in width when traced towards the ambitus; below this they decrease steadily. On the adoral surface ambulacra II and IV are curved posteriorly towards the peristome. Adorally, the ambulacral plates are all primaries and have become higher and narrower; near the peristomial depression and within it, the ambulacra are slightly depressed. Three plates (including the first, single plate) in each interambulacrum are situated in the peristomial depression, together with four or five plates in each ambulacrum. Two or three of these ambulacral plates each bear, in addition to the outer depressions (presumably containing the pore-pairs), a pit near the perradial suture (Text-fig. 1*e*).

The ornamentation consists of small, crowded, sunken tubercles, which are unfortunately more or less weathered in all specimens. Within the petals, the tubercles are usually arranged as shown in Text-fig. 1*f*; when the interporiferous areas are larger, however, each plate bears two, or rarely three, tubercles. In the ambulacra outside the petals, each plate possesses a row of horizontal tubercles; at the ambitus each row contains four or three tubercles in the larger specimens, two or one in the smaller; the number of columns of tubercles in an ambulacrum at the ambitus varies from eight to three. Within the peristomial depression the tubercles are smaller, more crowded, and the scrobicule is less marked or even missing; the tubercles thus approximate to granules.

Aberrant Variation.—One specimen (No. 108) shows tetramerous symmetry. Specimen No. 64 possesses, apparently, a fifth (posterior) genital pore. Some forms show constrictions in the ambulacra; for instance, ambulacrum III, in specimen No. 18, is constricted at the ambitus.

Discussion.—*O. ovumserpentis* (Guppy) is a common and widely varying species from the Eocene of the West Indies. By the kindness of Dr. Bather, I have been allowed to examine five West Indian specimens in the collection of the British Museum (Natural History). The ambulacral plating-structure of these specimens (E 10652–3, 17209–11) is similar to that of the Peruvian forms. Some of the figures given by Cotteau show large periprocts, but the periproct from its exposed position is easily enlarged by weathering, and all descriptions state that the periproct is small. The West Indian forms appear to be generally larger, and the dimensions of the largest example quoted by Cotteau (op. cit., 1875, p. 21) are nearly twice those of the largest Peruvian form; further, the small forms of the latter cannot be matched in size among the figured West Indian forms. The only other discrepancy between the Peruvian and the West Indian forms lies in the ratio between the width of the interporiferous area and the adjacent pore-field at the line of greatest width of the petal. In the majority of the Peruvian forms, this ratio is one or less than one. In some examples (e.g., the form figured in Pl. XXVI, Fig. *e*, and the exceptional form figured in Text-fig. 1*b*) it approaches that of the holotype of the species (Guppy, op. cit., fig. 4*b*; compare Jackson, op. cit., fig. 4).

Clark and Twitchell follow Stefanini in referring *E. ovumserpentis* Guppy to *Oligopygus* de Loriol (1887, *Notes pour servir à l'Étude des Échinodermes*, 1 Série, No. II; *Recueil Zool. Suisse*, iv, pp. 76–7). The opinion of Clark and Twitchell is especially valuable, since they re-examined the type-species; they further amended de Loriol's diagnosis to include other species. *O. ovumserpentis* fits the amended diagnosis; one point only calls for comment. Clark and Twitchell state (op. cit., p. 166): "Beyond the petaloid portions to and beyond the ambitus each plate is perforated at its outer end by two or three pairs of very small pores." They unfortunately did not figure this structure which it seems possible may be equivalent to the ambulacral plating-structure described above. Should the ambulacral plating-structure of the type species of *Oligopygus* prove to be different, it will be necessary, of course, to erect a new genus for *E. ovumserpentis* Guppy.

Comparison with other species.—Of the three species described by Clark and Twitchell, *O. haldermani* (Conrad) (op. cit., 1915, pp. 167–9, pl. lxxviii, figs. 4–5) most closely resembles *O. ovumserpentis*; but all three are easily distinguished by the much larger size of the depression round the peristome. *O. ovumserpentis* is distinguished from *Echinolampas lycopersicus* Guppy, with which it has been compared by Jackson (1922, pp. 61–2), by the "very evident floscelle" (op. cit., p. 64) of the latter. I have been unable to find a description of *O. alvaresi* Lambert and Roig, mentioned by Lambert and Thiéry (1924, *Essai Nomenclature Échinides*, Fasc. vi, vii, p. 388), in the reference they give.

Oligopygus sp.

Text-figs. 1 *h–i*, *k–m*.

Material.—One specimen. The peristome is obscured by matrix and I have been unable to expose it; portions of the corona are missing.

Description.—Its dimensions in mm. are:—

Length (*L*).	*Width* (*W*).	100 *W*/*L*.	*Height* (*H*).	100 *H*/*L*.
13·4	10·5	78·4	8·3	61·9

Test inflated. Adapical surface rounded: highest point slightly eccentric posteriorly. Ambitus rounded, midway between the adoral and adapical surfaces. Ambital outline inflated, oval, with very slight constrictions at the points where it is crossed by the pore-fields; line of greatest width eccentric posteriorly.

Apical disc eccentric posteriorly; four genital pores. Peristome central, sunken, apparently sub-quadrangular in outline. Periproct small, oval, submarginal, transversely elongated.

Petals open, short, extending slightly more than half-way towards the ambitus; about nineteen pore-pairs in each pore-field of petals I and V, fourteen in II and IV, and twenty-five in III. At the line of maximum width of each petal, the width of each interporiferous area is about twice the width of each pore-field; both the outer and the inner rows of pores converge from this line towards the ambital end. Inner pores circular, outer slightly elongated. Outside the petals the pore-pairs are well developed and regularly biserial. The plating-structure of the ambital end of the petal is seen in ambulacrum II (Text-fig. 1*k*), and the arrangement of the pores and tubercules in ambulacrum IV (Text-fig. 1*m*); both are essentially the same as in *O. ovumserpentis* var. *baldryi.*

Comparison.—This specimen differs from *O. ovumserpentis* (the only species of *Oligopygus* which it at all resembles) chiefly in its relative height (61·9 per cent), which is greater than that quoted above as the maximum for *O. ovumserpentis*; and further, in its low relative width, its short petals, and the lack of inflation of its petals and apical disc.

Genus RHYNCHOPYGUS D'ORBIGNY.

R. peruvianus sp. nov.

Pl. XXVI, Figs. *a–d*; Text-figs. 2 *a–g*.

Material.—Seven specimens, of which two (Nos. 5 and 6) are weathered internal casts. No. 7 is laterally compressed, and the adoral surface is missing. The holotype (No. 1) is complete, although weathered, the ornamentation being partially removed and the sutures developed. The floscelle and the ornamentation of the adoral surface are well preserved in No. 2, the apical disc, the petals and the ornamentation of the adapical surface in No. 3; Nos. 2 and 3 are therefore used as paratypes.

Measurements.—The dimensions in mm. of the specimens are:—

Specimen.	*Length* (*L*).	*Width* (*W*).	100 *W*/*L*.	*Height* (*H*).	100 *H*/*L*.
1 (holotype)	26·8	24·8	93	16·5	62
2 (paratype)	29·7	25·5	85	16·9	56
3 (paratype)	27·9	26·0	93	14·2	51
4	26·0	25·0	96	(?) 14·7	(?) 56
5	24	21·25	89	12·9	54
6	23	21	91	13·5	59
7	32	—	—	—	—

Description of Holotype.—Adapical surface subconical, highest point eccentric anteriorly. Ambitus slightly (*circa* 3 mm.) above the adoral surface. Ambital outline inflated, oval, the greatest width distinctly eccentric posteriorly; posterior margin truncated. Adoral surface slightly concave.

Periproct oval, transversely elongated, *circa* 5·0 × 3·2 mm.;

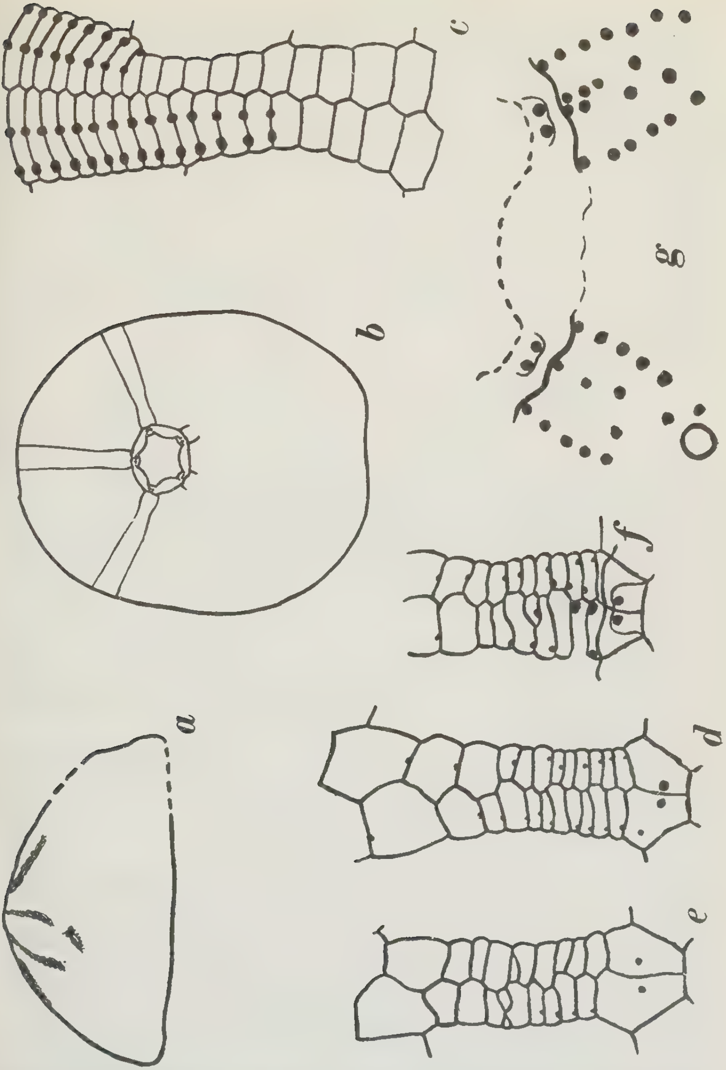


FIG. 2.—*Rhynchopygus peruvianus* sp. nov. *a*, outline from right side; specimen No. 3; × 1. *b*, adoral surface, showing outline, peristome and floscelle, and adradial sutures; slightly restored; No. 2. × 1. *c*, plating-structure and pore-fields of the region round the ambital end of petal V; holotype; × 4. *d–g*, plating-structure and pores of phyllodes. *d*, ambulacrum IV; *e*, amb. I; both very weathered; holotype; × 5. *f*, amb. IV, weathered; × 6. *g*, amb. I and V, with intermediate bourrelet; position of the margins of the inflated regions (the bourrelet and the ambulacral ridges) indicated diagrammatically by lines; × 4. No. 2. Magnifications approximate.

appearing as a notch in the antero-posterior outline of the corona; at its own height above the adoral surface. The ambital margin of the periproct is situated in a slight sulcus, so that the adapical margin is vertically above it.

Peristome eccentric anteriorly, pentagonal, transversely elongated, *circa* 4·0 × 2·5 mm.; situated anterior to the most depressed point of the adoral surface.

Apical disc small, eccentric anteriorly; at the (flattened) apex of the test.

Petals lanceolate, open, extending more than half-way towards the ambitus; the posterior pair being the longest, and the anterior (unpaired) petal the narrowest; the dimensions in mm. are approximately:—

	I and V.	II and IV.	III.
Length of Petal	13·0	11·5	11·5
Greatest Width	4·0	4·1	(?) 3·5
Width at ambital end	—	1·9	—

The petals have their greatest width midway between their adapical and ambital ends; in petals II and IV, the pore-fields at the ambital ends tend to become parallel. Each pore-field in the paired petals contains about thirty-five pore-pairs, with the exception of columns I*b* and V*a*, which are longer by some six pore-pairs (Text-fig. 2*c*). The outer pores are oval, the inner circular; they are not united by grooves.

Phyllodes moderately developed (Text-figs. 2*d–e*). All are very weathered; they are denuded of ornamentation, and the sutures are developed. They show the characteristic triad grouping, with occasional occluded plates.

Description of Paratypes.—Specimen 3. Apical disc with four large genital pores; anterior pores 0·7 mm. apart, posterior 1·2 mm. apart. The ornamentation is nowhere well preserved. Adapical surface crowded with small, deeply sunken tubercles; on the adoral surface the tubercles are larger and further apart.

Specimen 2. On the interradial tract of the posterior interambulacrum, the tubercles are replaced by crowded granules. Floscelle (Text-figs. 2*f–g*) with crescent-shaped bourrelets covered with granules; the ambulacral plates adjoining the peristome are thickened near their adapical margin, thus forming in each ambulacrum a curved ridge connecting the adjacent bourrelets, and slightly overhanging the adjacent ambulacral plates. The two pores near the peristomial margin in each ambulacrum are situated in a depression. Within each phyllode, the ornamentation consists entirely of granules.

Comparison with other Species.—*R. peruvianus* is distinguished from other forms of the same genus by the shape of the adapical surface, and to a less extent by the high value of the ratio height : length. The ambulacral ridges connecting the bourrelets are also probably distinctive; but in erected species the floscelle has often not been described in detail, and in some cases the species have been founded on weathered material.

Of American species *R. peruvianus* in shape most closely resembles "*Cassidulus* (*Pygorhynchus*)" *gouldi* (Bouvé) (see Clark and Twitchell, op. cit., 1915, pp. 171–2, pl. lxxix, fig. 3; pl. lxxx, figs. 1, 2); but the latter is easily distinguished by the relatively smaller and less transversely elongated peristome and the more adoral position of the more oval periproct. As far as can be determined from the figure given of a weathered phyllode, an ambulacral ridge somewhat similar to that of *R. peruvianus* connects the bourrelets in "*C.* (*P.*)" *conradi* Conrad *ex* Couper MS. (see Clark and Twitchell, op. cit., pl. lxvii, fig. 1*f*); but the two species are easily distinguished by, for instance, their shapes.

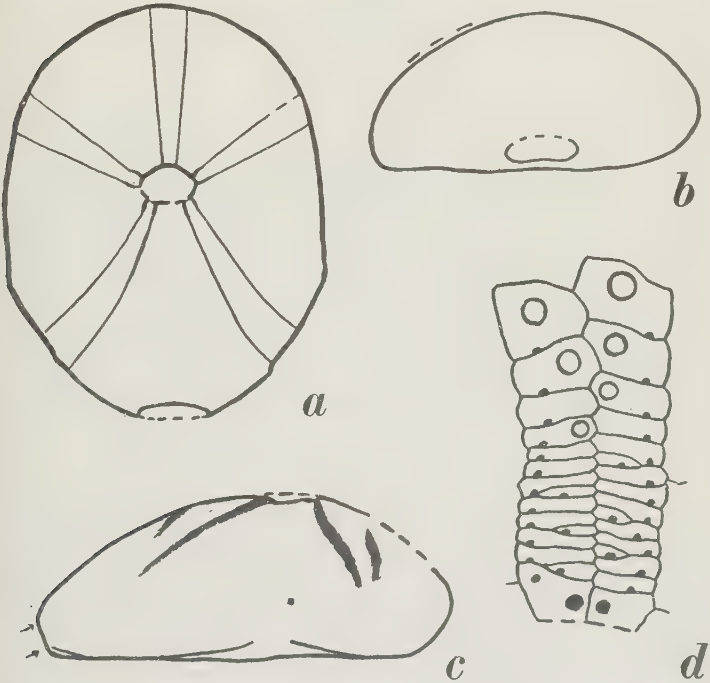


Fig. 3.—*Echinolampas atascaderensis* sp. nov. Holotype. *a*, adoral surface, showing periproct, peristome, and adradial sutures; × 1. *b*, outline from the posterior end; the left side of the specimen has been slightly crushed, displacing the ambitus and increasing the width; × 1. *c*, outline from the right side, showing position of peristome and posterior sulcus as though in section; position of periproct indicated by arrows; × 1. *d*, phyllode in ambulacrum IV, weathered; slightly restored by comparison with ambulacrum II; × 8. Magnifications approximate.

Genus ECHINOLAMPAS Gray.

Echinolampas atascaderensis sp. nov.

Pl. XXVI, Fig. *i*; Text-figs. 3*a*–*d*.

Material.—Seven weathered specimens are referred to this species, four doubtfully. The holotype, No. 1, is slightly crushed, and the apical disc is missing; specimen No. 2 is crushed, but has the apical disc and the petals are less weathered.

Measurements.—The dimensions in mm. are approximately :—

Specimen.	*Length* (*L*).	*Width* (*W*).	100 *W*/*L*.	*Height* (*H*).	100 *H*/*L*.
1	57·5	46	80	22·5	39
3	56	46	82	23	41

Description of Holotype.—Adapical surface inflated, highest point eccentric anteriorly. Ambital outline roughly pentagonal; anterior margin rounded, posterior wedge-shaped, but truncated by the periproct; greatest width eccentric posteriorly, at a line one-third of the coronal length from the posterior margin. Ambitus tumid, one-third of the coronal height above the adoral surface. Adoral surface slightly depressed round the peristome, and in interambulacrum 5 near the posterior margin.

Peristome pentagonal, transversely elongated, eccentric anteriorly. Periproct transversely elongated, sub-marginal; below the ambitus, and sloping at an angle of *circa* 120° to the adoral surface; the adapical margin (which coincides with the ambitus) thus overhangs the lower.

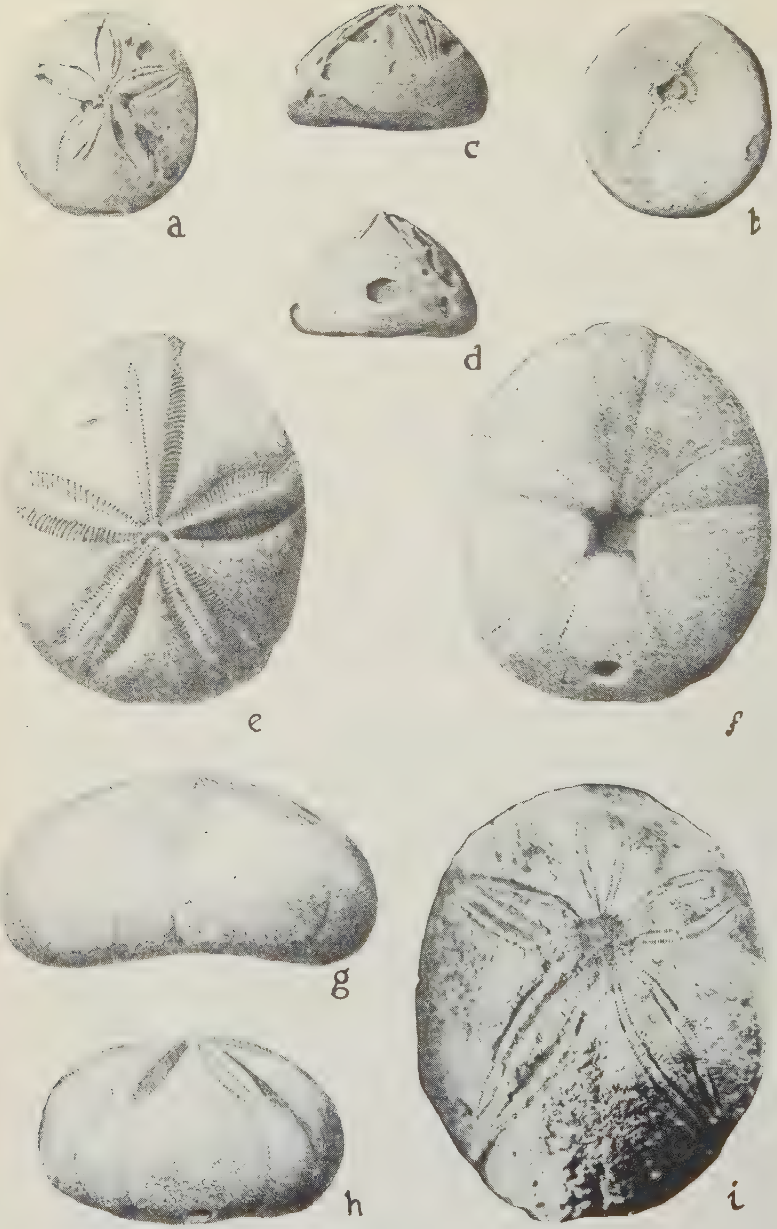
Apical disc eccentric anteriorly, and (?) anterior to the highest point of the corona. Petals lanceolate, reaching nearly to the ambitus; petals I and V the longest (containing approximately seventy pore-pairs in each pore-field), petals II, III and IV equal in length (containing about 60 pore-pairs). Line of maximum width half-way between the adapical and ambital ends; petal III relatively the narrowest. Pore-fields narrow (less than half the width of the petal at the maximum width); the two pore-fields of each petal are parallel at the ambital end.

Phyllodes moderately developed (Text-fig. 3*d*). Phyllode III is less developed than the others, since the plates are higher and are all primaries, and the adradial sutures are approximately parallel.

The ornamentation consists of sunken tubercles, which are smaller and more crowded on the adapical surface.

Description of Paratype, Specimen 2.—Apical disc small; four genital pores, the anterior pair 1·2 mm. apart; madreporic pores occupy the whole of the space between the genital pores and extend between ocular pores I and V. Each pore-field of petals II (column *b*) and III (column *a*) contains more than sixty-three pore-pairs, of petal I (column *b*) more than seventy.

Comparison.—*E. atascaderensis* is obviously distinct from all American forms with which I am acquainted.



C. Barrington Brown, del.

ECHINOIDS, N.W. PERU.

To face p. 371.]

EXPLANATION OF PLATE XXVI.

FIGS. *a–d.—Rhynchopygus peruvianus* sp. nov., holotype. *a*, adapical view. *b*, lateral view (right side). *c*, adoral view. *d*, posterior view. × 1.

FIGS. *e–h.—Oligopygus ovumserpentis* (Guppy), specimen No. 8. *e*, adapical view. *f*, adoral view. *g*, lateral view (left side); posterior view. × 2.

FIG. *i.—Echinolampas atascaderensis* sp. nov.; holotype; adapical view. × 1.

(*To be concluded*).

The Echinoid Genus *Oligopygus* De Loriol.

By HERBERT L. HAWKINS, D.Sc., F.G.S., Professor of Geology, University of Reading.

A HYPOTHESIS can be confirmed most effectively when the deductions drawn from it prove correct. When such deductions take a prophetic form, fulfilment becomes most convincing. It is gratifying thus to discover confirmation of the prognostications of a predecessor; I hope a certain ebullition of satisfaction may be pardoned since I am here in a position to use the often provocative expression " I told you so " !

In 1920 (*Phil. Trans. R. Soc.*, B., vol. ccix, p. 461), in a discussion of the relation between the Echinonëidae and the Echinolampidae, I came to the following conclusion. " . . . the ambulacrum of the Echinonëidae could readily have given rise to that of the Cassiduloida. *Amblypygus* seems to show the modification of the apicad pores, while *Conulus* has structures preliminary to the modification of the orad pores. All that is needed to complete the history of the transformation is a case in which the plating is in process of simplification. That such evidence will be found in Cretaceous or Lower Tertiary Cassiduloida I am confident ". The purpose of the present note is to demonstrate that the confidence was justified and that the evidence is now available.

In the course of research on a large series of Tertiary Echinoids collected in Jamaica by Dr. C. A. Matley (the systematic results of which will appear shortly), I was confronted with a wide range of examples of the common " *Echinolampas* " *ovumserpentis* Guppy, which is characteristic of the Eocene of the West Indian region. Several of the specimens are weathered in such a way that the details of their plating are beautifully clear, in spite of their minute character. The species was separated from *Echinolampas* and referred to *Oligopygus* by Stefanini in 1911, and there can be no doubt as to the rightness of this ascription. Indeed, almost the only serious point of difference between *O. ovumserpentis* and *O. wetherbyi* (the genotype) seems to be the absence or feeble development of a peristomial " pocket ' in Guppy's species. On evidence gathered from the numerous specimens collected in Jamaica, I am by no means convinced that this " pocket " is a true specific character—whether it has a sexual or merely individual significance can hardly be decided. But the differences between the two species are so trifling that there is little risk in ascribing the structures in *O. ovumserpentis* to the genus *Oligopygus.*

It is difficult to find a suitable resting place for this genus in any accepted scheme of classification. It seems on most counts to be a good example of an annectant type, combining many of the features proper to the three orders Holectypoida, Clypeastroida, and Cassiduloida. But its prominent petals are out of place in the first-named company, the edentulous mouth is contrary to all Clypeastroid traditions, while the ambulacral structure (apart from the petals) proves quite unlike that found in adult Cassiduloids. In 1920 I proposed to place it provisionally among the Holectypoids, in the family Echinonëidae; fuller acquaintance with its characters seems still to leave that as the best solution of the matter. A superficial examination of the adoral surface at once suggests "*Pyrina*", and apart from the position of the two main openings, the curved, unmodified shape of the ambulacra and the complexity of their plating, all encourage the comparison. It must, however, be admitted that a closer inspection shows that the complexity is but partially of a Pyrinid type. The adapical surface is similarly comparable with that of *Echinolampas*, but here again it is found that the distal end of the petals is quite anomalous. The adoral surface of the test is ontogenetically the oldest, and (in this case at least) the least specialized, and so may be expected to reveal relatively archaic characters. It is worthy of note that the development of *Echinolampas* (which is none too well known) shows a definitely Holectypoid stage, compared by A. Agassiz (in the "Revision") with *Discoidea*. Hence it seems more appropriate to leave this genus in the order that it seems to have barely left than to place it precociously in a group towards which it may have been progressing. Phylogenetically, I am inclined to consider *Oligopygus* as the next stage after *Amblypygus* in the transition from the Echinonëidae to the Echinolampidae.

The most thoroughly weathered specimen before me was collected from the Eocene Yellow Limestone near Spring Mount, St. James, Jamaica, and is registered in the collection of this department under the number R550. It shows the minute details of the ambulacral structure almost throughout; and although decay has advanced rather too far in some patches, in others the plating is so clearly exposed that there is no room for uncertainty as to its quality. The weathering even reaches to the border of the peristome, a state of affairs always desired but rarely realized. The specimen is of the size normal to those from Jamaica (about 30 mm. long, 26 mm. broad, and 17 mm. high), almost perfectly elliptical in outline, flattened above and below, with practically no peristomial invagination. As is usual in the genus, the test is inordinately thick.

The first point in ambulacral structure that calls for comment is the relation of the petal to the continuation of the area (Text-fig. 1). It will be noticed that the distal part of the petal embraces the proximal part of the ordinary area. This is the exact converse of the normal relation between the two regions, where (in Clypeastroid or Spatangoid types) the petals either pass gradually into the non-petaloid parts or are, as it were, let into them (see Text-fig. 3). As far as my experience goes, this invert structure is peculiar to *Oligopygus*. Its effect is to make the petal appear as an altogether separate and independent development—a sort of afterthought. Save for minor irregularities, the petal consists wholly of primary plates, while the non-petaloid region is complex. This again is a condition exactly opposite to that usual in petaloid ambulacra.

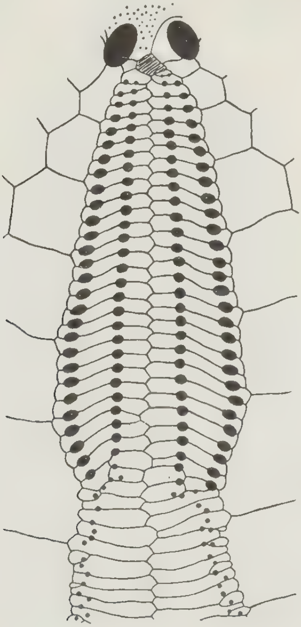


Fig. 1.—Petal III of *Oligopygus ovumserpentis*, with subjacent parts of the ambulacrum.

Turning to the extrapetaloid region, we find the structure more or less constant in character from the ends of the petals to the immediate vicinity of the peristome. There is no phyllode, but rather the reverse, for the few plates near the peristomial border are the only simple primaries present (Text-fig. 2). As a general rule, the plating consists of primaries alternating with exceedingly minute demi-plates. Occasionally (on the adoral surface only) two demi-plates may occur in conjunction after the Discoidiid pattern; and not infrequently a demi-plate may be wanting. Wherever the normal alternation of large and small plates occurs, it is seen that there is a single, relatively large, pore in each plate. But in the cases where the demi-plate is wanting there are always two such pores in the primary plate (see especially Text-fig. 1). In one or two cases, where the demi-plate is present, but exceptionally minute, it is imperforate, and two pores occur in the adjacent primary. The pores are placed alternately nearer to and further from the adradial suture, those of the demi-plates usually having the former position. There is no interference with this arrangement when the demi-plate is absent. Cotteau described the poriferous zones beyond the petals as consisting of "pores in single series ranged obliquely". It would seem that by "pores" he meant "pore-pairs". Certainly his description would be quite accurate if the pores were paired; but in view of the structure revealed by this specimen it is clear that the description needs amendment in such a way that it would read "single pores in biserial order". There is another specimen in the collection where the pores seem to be actually paired in places, producing extreme congestion in a manner that is still biserial. Possibly this paired condition is the true one, and undue weathering may have blended the pairs in the specimen figured, but there is no direct reason for suspecting this.

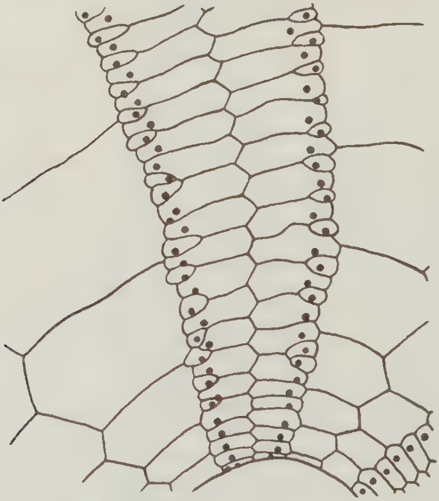


Fig. 2.—Orad part of area II of the same specimen (Reading Univ., Geol. Dept., R 550). Both figures are similarly, and greatly, enlarged.

It seems clear that *Oligopygus* shows an ambulacral state analogous to that occurring in *Noetlingia* among the Regular Echinoids, where a series of reduced plates is in process of obliteration. In that genus the pores are dwindling with the plates; but in this case the pores are retained even when the plates have gone. In 1920, when I expressed the belief that further discoveries would reveal the process of simplification from Pyrinid triads to Cassiduloid primaries, I knew *Oligopygus* by figures and descriptions only. Had I known the structure of the ambulacrum in the genus, the prophecy would have been superfluous.

It would appear that very little change (apart from local resorption) has affected the ambulacral plates in this species since their genesis at the ocular margin. Hence it is reasonable to treat the area, as traced from peristome to apex, as a fairly complete and reliable record of growth-stages, just like the whorls of a Gastropod or Cephalopod. The earliest ambulacral plates (those nearest the peristome) were all primaries, and these were succeeded by occasional but sufficiently suggestive Discoidiid triads. But in general the plates that preceded petal-growth were in the condition found as a gerontic feature in *Discoidea* and as a normal feature in the petals of *Clypeaster* (Fig. 3) and *Arachnoides*. Last of all the petal plates were produced with, as it were, an unconformable junction on the preceding series. Modifications subsequent to production of the plates are restricted to reduction and occasional resorption of the demi-plates in the non-petaloid parts.

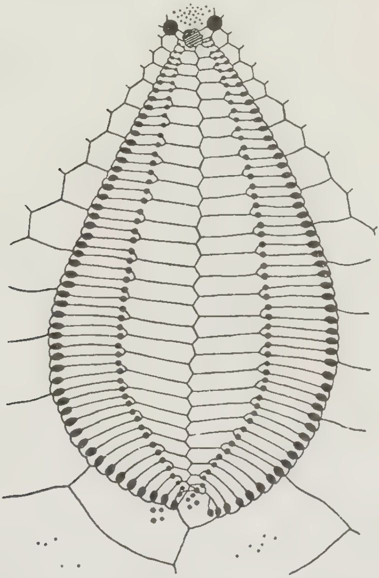


Fig. 3.—Petal II of *Clypeaster lanceolatus* Cotteau.

From the scanty evidence available it appears that the living Echinolampads have, in an early post-larval stage, ambulacral plates that are grouped into triads and are quite non-petaloid. The petals do not appear until fairly advanced adolescence. In the adult *Echinolampas* (Fig. 4) the triads are retained (with changes in proportions) in the phyllodes, and the rest of the areas consists of primaries which become petaloid adapically. In ontogeny there seems a definite tendency to skip unnecessary stages in recapitulation, so that the demi-plates, which are slowly resorbed during life in the ancient *Oligopygus*, are cut out of development altogether in the recent *Echinolampas*.

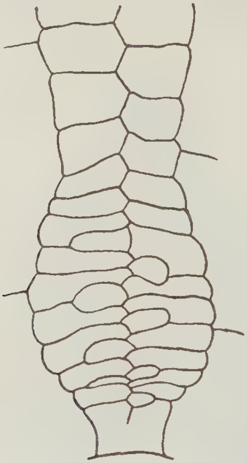


Fig. 4.—Phyllode II of *Echinolampas anguillae* Cotteau (pores omitted).

Hence, if we call *Amblypygus* (which has the Pyrinid type of plating throughout its ambulacra, even in the petals) an *Echinonëus* with petals—and no more succinct and accurate description of that genus seems conceivable—then *Oligopygus* must be regarded as an *Echinonëus* undergoing ambulacral simplification adorally, and as an *Echinolampas* with practically full characters adapically. It is hardly hyperbolic to suggest that the " missing link " between the Echinonëidae and Echinolampidae is to be found just above the ambitus of *Oligopygus*.

In conclusion, it may be surmised that the discovery of the simplification of ambulacral structure in the Cassiduloid line of descent brings with it two corollaries besides its morphological interest. In the first place, it confirms the belief that the Cainozoic Echinolampads are phyletically distinct from the Mesozoic Nucleolitids and Pygurids; and secondly it enhances the probability of the suggestion that the large, multiporous primaries of the non-petaloid parts of Clypeastroid ambulacra originate through simplification of the extremely complex Discoidiid type of structure. Material proof of that contention awaits discovery in species of late Cretaceous or early Tertiary date.

REVIEWS.

The Carlisle Basin.

The Geology of the Carlisle, Longtown and Silloth District. By E. E. L. Dixon, J. Maden, F. M. Trotter, S. E. Hollingworth, and L. H. Tonks. Mem. Geol. Survey, pp. viii + 113, with 4 plates and 4 text-figs. 1926. Price 2s. 6d.

THE geology around Carlisle has received different interpretations owing to the cover of glacial drifts, the scarcity of exposures, and the hidden disturbances. A new edition of the Geological Survey Maps (Sheets 11, 16 and 17), and a new memoir on the area west of Carlisle make several changes from the first editions, some of which are for the better ; others appear less probable than the earlier interpretation. T. V. Holmes, in his papers and memoir on the district, classified the beds in descending order as follows :—Stanwix Marls, Kirklinton Sandstone, Upper Gypseous Shales, St. Bees Sandstone, Lower Gypseous Shales, and Penrith Sandstone. His Upper Gypseous Shales were nowhere seen on the surface, but were traversed by bores at Abbeytown and Bowness, and probably at Great Orton, and were claimed as distinct from the Lower Gypseous Shales, as Holmes identified the rock at the bottom of the Abbeytown bore as the St. Bees Sandstone. In a paper, Geological Magazine, 1915, pp. 241–9, I held that this identification was incorrect, and that there were only two clay series instead of three. Both these contentions are accepted in the new edition (1926) of the Geological Survey Memoir ; but its interpretation of the area is based on Aveline's view that the Gypseous Shales of Abbeytown and Bowness are the thickened western extension of the Stanwix Marls. The authors identify the sandstone at the bottom of the Abbeytown and Bowness bores as the Kirklinton Sandstone. This identification is more plausible than Holmes' view, as both the Kirklinton and the Penrith Sandstones are red and falsebedded, and hand specimens may be indistinguishable. The characteristic feature of the Kirklinton Sandstone is its bright red colour, which has been described as scarlet. The Memoir, p. 27, refers to " the typical scarlet Kirklinton type ". The rocks at the base of the Abbeytown bore on the other hand are recorded as grey sandstone, blue sandy shale, grey grits, grey and white sandstone, as well as red sandstone. These descriptions agree better with the Penrith than with the Kirklinton Sandstone.

There is more evidence available regarding the proposed identification of the Gypseous Shales of Bowness and Abbeytown with the Stanwix Marls. The Stanwix Marls are described as characteristically red, green, and greenish-grey. The colour green is not once mentioned in the bore record of the Bowness shales, which are red, grey, white and blue. The journal of the Abbeytown bore mentions colour 103 times—red 53, blue 19, green 17, white 7, grey 6, purple 1. Hence blue is more frequent than green.

The two sets of beds differ in composition as well as in colour. The Stanwix beds at Carlisle are mainly marls, and they have been regarded as the representatives of the green marls of the Rhaetic. The Survey Memoir, p. 29, in describing the section at Beaumont mentions 11 beds, including 8 of marl, a dark limestone, a grey-green sandstone, and a shale. The Abbeytown journal mentions neither marl nor limestone, but 36 occurrences of gypsum and one of salt, neither of which are seen in the marls of Stanwix. The Memoir correlates the gypsum-bearing series of Abbeytown, not with the similar Gypseous Shales 4 miles south of Carlisle, but with the remarkably different marls at Carlisle.

The Stanwix Marls also differ from the Gypseous Shales in thickness. According to Holmes they are very thin at Carlisle. He issued a figure (Geol. Assoc. Record of Excursions, 1891, p. 533) entitled " Section to illustrate the necessary thinness of the Stanwix Marls in Caldewgate, West of Carlisle ". According to the Aveline hypothesis the Stanwix Marls suddenly increase greatly in thickness, and at the same time completely change their character. The view that the Stanwix Marls might be the continuation of the Abbeytown Shales was of course considered by Holmes, as it would have relieved him of serious difficulties ; but he rejected this correlation, and in this respect the evidence seems to support Holmes. The resurvey, in spite of its thorough scrutiny of the area, has produced no new material evidence in support of this correlation. Mr. Dixon has discovered a " wisp of green shale" a little further south of Carlisle than the Stanwix Marls were previously known ; and if its identification as such be correct, it would merely shift the Dalston fault 400 yards further south. That fault was adopted on the earlier map and by Holmes, and its existence is supported by the fact that the andesite dyke has not been traced west of the Caldew. The fault is, however, now omitted from the map, while great importance is attached to the Grinsdale fault, which was inserted on the earlier map as hypothetical, and for which there seems less evidence than for the Dalston fault. Holmes insisted that there was no evidence whatever for the Grinsdale fault, and he protested (Proc. Geol. Assoc., vol. xi, p. 247) in regard to it that " the invention of a fault where there is no evidence of one, simply in order to obtain a result in harmony with theoretical prepossessions, is, it seems to me, an utterly unsound and unscientific proceeding ". Holmes was equally emphatic in his rejection of the correlation of the Stanwix Marls and the Gypseous Shales. He stated (ibid., p. 246) " The Stanwix Marls may also be the Gypseous Shales with almost all the Gypsum left out, but nobody would suppose them to be identical but for theoretical prepossessions. The Stanwix Marls may also, after appearing to be very thin west of Carlisle, suddenly thicken out in the extraordinary way depicted, but it is highly improbable that they do so ".

The main reason in the Memoir for the rejection of the Abbeytown Shales as the Gypseous Shales which overlie the Penrith Sandstone is based on the ambiguous record of the bore at Great Orton in 1781. The record merely states that the bore reached " red stone or clay sometimes mixed with veins of white " ; but the Memoir refers to the bore as having " proved " red shales with gypsum underlying the Lias, and says that I accepted that view. I accepted the " veins of white " as probably gypsum, but pointed out (GEOL. MAG., 1915, p. 248) that they might be merely white sandstone and the beds instead of being the Gypseous Shales " might be either Stanwix Shales or Kirklinton Sandstone ". The argument of the Memoir is that if the beds at the Great Orton bore were the Gypseous Shales below the St. Bees Sandstone, the Lias would overstep the Kirklinton and St. Bees Sandstones, and it holds that such an unconformity is improbable. In an admirable discussion of the correlation of the Cumberland and Eastern red rock series, Mr. Dixon concludes that the Lower Gypseous Shales are the equivalent of the eastern Saliferous Marls and says that their Permian age has been established by their fossils. Considering the Upper Permian earth-movements in Cumberland, and that in some British localities the Lias rests on the Carboniferous, the superposition of the Lias (with perhaps Rhaetic below it) on the Gypseous Shales seems less improbable than the identity of the Gypseous Shales and the Stanwix Marls.

The identification of unfossiliferous beds separated by 14 miles of drift-covered country—with only the doubtful Orton Bore between—is necessarily uncertain ; and only boring can supply a conclusive test between the two interpretations. In the meanwhile as there are in three and perhaps four isolated localities around Carlisle a series of Gypseous Shales with similar lithological characters it appears more probable to regard them as one horizon rather than identify most of them with the strikingly dissimilar Stanwix Marls.

The Memoir contains interesting chapters on the Glacial Geology, on the Caldew andesite, and on the Economic Geology, and has an excellent bibliography.

J. W. GREGORY.

BERWICKSHIRE AND ROXBURGHSHIRE. By W. S. CROCKETT. pp. xii + 200, with 54 figs. and 5 maps. Cambridge University Press, 1926. Price 3s. net.

THIS excellent little volume is one of the Cambridge County Handbooks which deal in a general way with the geography, history, zoology and geology of the various provinces of Great Britain. Owing to the general character of the series, the geological descriptions must be of a very brief nature. Nevertheless, in this handbook we find an efficient summary of the essentials of Berwickshire and Roxburghshire geology put forward. The rocks from the Arenig pillow lavas up to the Calciferous Sandstone strata are shortly described and, what is most important for a book of this kind, typical localities are indicated.

If one can find any fault with the book it is that the geological map at the end is not sufficiently clear. The geological features are merely superposed on a very second-rate topographical map, so that the hill shading and rather coarse lines and printing obscure to a certain extent the geological details.

T. C. PHEMISTER.

STUDIER OVER ISRAND-TERRASSENE. By OLAF HOLTEDAHL, with a summary in English. Vidensk. Skrifter. I. Mat.-Naturv. Klasse, 1924, No. 14, Kristiania.

THE deposits laid down in the Oslo Fjord during the recession of the ice-front in that region, and reconstructions of the conditions which then obtained, are well known from Brögger's classic researches. In the present paper Professor Holtedahl describes those deposits from the north of Oslo up to the southern end of the "great lakes" region, which up to now have received little more than mention as moraines.

These so-called moraines are sandy, gravelly, and conglomeratic flats which are regarded as fluvio-glacial, being formed in close proximity to the ice-front, and at sea-level. Basin-shaped hollows ("kettles") and irregular valleys are ascribed to the subsequent melting of blocks and tongues of glacier ice which were buried beneath the fluvio-glacial deposits. Various stages in the recession are distinguished, and estimates of the position of the sea-level are based upon the supposition that the flats were formed at that changing level. As has been found to be the case in Sweden, these flats occur at lower levels as one proceeds inland, indicating successive uplift during the recession of the ice. As one flat was raised above sea-level sand dunes were piled upon it, valleys were scored in it, and the next flat formed at the new sea-level.

Brögger has maintained that during the recession of the ice-front to the southern end of the "great lakes" region the sea rose on the land, and that only after this considerable period of load removal did the shore line fall—the main support of this idea lying in the contention that the fauna of the older *Yoldia* clay outside the Ra moraines is a shallow water one. This conclusion has been given considerable prominence by some writers who have interpreted it as indicating that during the earlier stages of ice removal the rise of the sea-level due to the return of the melted ice was more rapid than the slow isostatic recovery of the land (W. B. Wright, *Quaternary Ice Age*). It is therefore of interest to note that Holtedahl does not accept this early submergence. Having established the fall of the shore-line during the recession of the ice from his area, he cites a fluvio-glacial flat at Mysen, which was laid down at the same time as the Inner Ra moraine of the Oslo Fjord, as indicating a sea-level which shows that there had been no rise of the shore-level since the Inner Ra period, a very early stage in the ice retreat. This conclusion is in accord with De Geer's contention with regard to the corresponding Swedish region, that " the land was already depressed to the greatest depth while it was covered by land ice ".

P. A. Øyen holds that the deposits described by Holtedahl date from a time of great ice advance (*Portlandia*-niveau) which followed a relatively mild inter-glacial period (*Mytilus*-niveau), during which the ice retired far into the mountain region of Central Norway; whereas Holtedahl finds no evidence for this marked climatic oscillation.

Scandinavian glaciologists are justly famed for the precision of their researches, and the fact that different interpretations are given of the origin of the same deposits is a reminder that one must walk warily. Where the conclusions drawn from inorganic evidences clash with those based upon faunas, those who agree that the latter must be revised will be impressed by Professor Holtedahl's views. This paper, which is copiously illustrated by maps and contains an adequate summary in English, will interest all students of glacial and isostatic problems.

L. Hawkes.

REPORTS AND PROCEEDINGS.

Mineralogical Society.

15th June, 1926.

S. I. Tomkeieff: " On some Chloritic Minerals associated with the Basaltic Carboniferous Rocks of Derbyshire."

In this paper the author has described certain leptochlorites occurring as vesicular infillings in the Carboniferous lavas (" toadstones ") of the North Derbyshire area. The chemical analysis of a finely spherulitic chlorite from Calton Hill places it definitely in the delessite-diabantite series. Some other chlorites from Miller's Dale are less crystalline and show a peculiar development of bacteria-like aggregates, similar to those observed in the chlorophaeite of Dalmahoy Hill, near Edinburgh. All these chlorites can be compared with the chloritic palagonite occurring in the mesostasis of the non-vesicular basalt of the same lava flow, and it is suggested that both varieties of chlorite are primary, and were formed during the final stages of the solidification of the magma (auto-pneumatolitic).

Dr. F. L. Stillwell: " On the Nature of Berthierite."

A chemical analysis of berthierite from Nullamanna, near Inverell, New South Wales, gave the formula $3FeS.4Sb_2S_3$. Microscopical examination of polished and etched sections of the material shows an intergrowth of about 18 per cent. of stibnite. Deducting this from the results of the chemical analysis, the formula of berthierite becomes $FeS.Sb_2S_3$.

Dr. L. J. Spencer: "A Sperrylite Crystal from the Transvaal."

Crystals of sperrylite (the rare platinum arsenide, $PtAs_2$) up to half-an-inch across have recently been found in the Potgietersrust platinum fields, Transvaal. The crystal examined measures 5·0 to 5·5 mm. across and weighs 1·294 gram. It is a brilliant cubo-octahedron developed on all sides and with the corners and edges much rounded. The rounded areas give a profusion of scattered reflected images, few of which lie in the principal zones on the crystal. The only forms identified with certainty are (100), (111), (110), (210), (211).

H. E. Buckley: "The Anomalous Optical Properties of some new Series of isomorphous Double Tartrates."

In addition to the mixed crystals $[m\mathrm{NaK}, n\mathrm{Na(NH_4)}]\mathrm{C_4H_4O_6}.4\mathrm{H_2O}$, previously examined, optical anomalies of the same kind have now been determined for the series $[m\mathrm{KNa}, n\mathrm{K(NH_4)}]\mathrm{C_4H_4O_6}.4\mathrm{H_2O}$ and $[m\mathrm{(NH_4), Na}, n\mathrm{(NH_4), K}]\mathrm{C_4H_4O_6}.\ 4\mathrm{H_2O}$. All these crystals are orthorhombic and isomorphous, but when freshly prepared they show crossed dispersion characteristic of monoclinic crystals (borax type). On standing, the crystals show a slow change in the size of the optic axial angles and in the position of the optic axial planes for different colours; and finally, after a lapse of some time, they settle down with all the optic axial planes lying in the plane (100) or (010) or in both, giving in the latter case crossed axial-plane dispersion of the orthorhombic (brookite) type. This change is hastened by rise in temperature and retarded by pressure. Sections from the outer and inner portions of the crystals showed a difference, evidently due to the time taken for growth; but in the final state they are identical, suggesting that the crystals are homogeneous. Other isomorphous series of mixed crystals containing only two of the three bases, namely $[m\mathrm{Na_2}, n\mathrm{Na(NH_4)}]$, $[m\mathrm{(NH_4)_2}, n\mathrm{(NH_4)Na}]$, $[m\mathrm{Na_2}, n\mathrm{NaK}]$, and $[m\mathrm{K_2}, n\mathrm{KNa}]$, showed, in the range of the visible spectrum, the optic axial planes all in one plane, but with wide differences in optic axial angle.

D. G. T. Prior: "On the South African Meteorites, Vaalbult, Witklip, and Queen's Mercy."

The Vaalbult meteoric iron is a very deeply and broadly pitted mass weighing about 26 lb., found on a farm in the Prieska Division, Cape Province. It is a coarse octahedrite having a percentage of nickel of about 7. The Witklip meteoric stone fell on 26th May, 1918, at about 9.40 a.m. after appearance of a luminous meteor and loud explosions, on the farm Witklip in the Carolina District, Transvaal. Fragments weighing together only about 22 grams appear to have been preserved. It is a grey chondrite closely resembling the Cronstad meteoric stone. Of the Queen's Mercy meteorite a large stone, a foot and a half long, fell on 30th April, 1925, at Queen's Mercy, about 20 miles from Matatiele and was broken into small pieces by the natives. A second complete smaller stone weighing about 950 grams which fell about 15 miles from Matatiele was obtained from Chief Jeremiah Moshesh, and is now in the Natal Museum at Pietermaritzburg. It is a veined grey bronzite-chondrite containing about 15½ per cent. of nickel-iron, in which the ratio of iron to nickel is about 10½, and about 5½ per cent. troilite, and having a ratio of magnesia to ferrous oxide in the pyroxene of about 5.

CORRESPONDENCE.

THE CENTRAL RANGE OF TRINIDAD.

Sir,—Dr. Trechmann's brief paper on the Northern Range of Trinidad in the December number leads me to say that now nobody, I believe, would consider the Northern other than older than the Central Range. The structure of the latter is exceedingly complicated, presumably it is fundamentally an anticlinorium; and after five years in the Island, with the advantage of going over a large proportion of the ground with my colleague, Mr. W. B. Hume, who did much detailed work around Tamana and Brigand Hill, and with other geologists, one felt in 1920 that there remained many gaps in our knowledge to be filled in. Since that date many of these may have been bridged, and consequently other workers may be more competent to speak, but as matters then stood, the Central Range was held to consist of Barremian, Cenomanian and Priabonian cherts, grits, limestones and shales, extending almost across the Island and having a breadth of two to three miles. The grits with grains of bluish quartz were considered characteristic.

Mr. Bullen Newton has recently described the *Inocerami*, which occur, very rarely, in black shales intercalated in the cherts, white and grey banded rocks, breaking into columnar fragments and being apparently unconformable inliers.

The identification of the Cenomanian limestone from the eastern end of the Range, about 5¼ miles W.S.W. of Brigand Hill is due to Dr. Sommermeier, that from Pointe à Pierre, where Mr. Penny has done much work, to Messrs. G. D. Harris and Floyd Hudson.

The Priabonian beds of Morne Roche Quarry, about eight miles E.N.E. of Pointe à Pierre, are dated by the occurrence of a *Clypeaster*.

Speaking broadly, on either side of this ridge of Palaeogene and Cretaceous rocks lie Miocene deposits, Upper Aquitanian to Vindobonian, laid down in two separate basins of deposition, the whole, especially in the neighbourhood of Tamana, being much faulted, probably by pre-Pliocene movements. Fossils from several localities, e.g. the Matchapoorie Quarry and Cumuto Road (17 miles), are probably Lower Miocene, and perhaps Middle Miocene from the Manzanilla Coast. These have recently been described by Mansfield of the U.S.G.S. As the Miocene beds differ somewhat on the two sides of the Range, it is convenient to call the more northerly the Brasso Sands and Clays, from a locality where they are well developed.

These flanking sands and clays include a "rubbly" coral limestone, occurring sporadically throughout, but especially along the northern edge on the west. This may be known as the Guaracara limestone, and often contains *Amphistegina* in quantity. To the south of the ridge of older rocks stretch the Naparima Series, consisting of radiolarian beds, yellow marls crowded with *Globigerina* in astonishing abundance, and clays, frequently full of foraminifera, *Cyclammina* being considered characteristic.

In the Central Range the backbone of older rocks is cut off by a N. and S. fault to the W. of Brigand Hill and replaced by a northerly dipping monocline of Miocene beds continuing to the Coast of Manzanilla.

A simple way of visualizing Trinidad, in very general terms, is to consider it as consisting of three ridges of hills, the Northern, Central and Southern Ranges, these being as a whole progressively younger in a southerly direction; the intermediate valleys, to what extent bounded by faults it is hard to say, being infilled with Miocene and Pliocene beds.

JOHN PARKINSON.

THE THEORY OF MAGMATIC CYCLES.

SIR,—Owing to my absence from home I did not receive the galleys of my paper in the July number of this MAGAZINE until, as I found later, it had already gone to press. This must be my excuse for certain infelicities of expression and incomplete references to literature which otherwise would not have been allowed to pass. I should like, however, to take this opportunity of correcting a few misprints that may cause unnecessary confusion:—

p. 310, footnote 2, *for* "section 6" *read* "section 7".

p. 313, line 9, *for* "ans" *read* "and".

p. 314, caption 4A, *read* "The Zone of Flowage around a *growing* Bathylith".

p. 315, line 29, *for* "condition" *read* "conditions".

p. 315, section B, line 11, *for* "temperature" *read* "temperature of fusions".

p. 319, footnote 2, *for* "p. 165" *read* "p. 765".

p. 326, line 6, *for* "clean water" *read* "ocean water".

Fortunately these corrections and a few minor alterations have been made in the reprints of the paper.

ARTHUR HOLMES.

UNIVERSITY OF DURHAM,
9th July, 1926.